POWER

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Thinking

IT IS said that the ability to think is what distinguishes man from the lower animals.

I don't know as I can subscribe to that, for I have known not a few animals that evidently thought things out very cleverly.

But I will agree that the ability to think is what distinguishes some men from other men.

It seems to hurt some men to think. It does require an effort, and mental effort may be as onerous as physical exertion.

And mental fatigue may be as depressing and bear as heavily on one as bodily weariness.

The laborer whose muscles are hardened by habitual toil can get away, without apparent effort, with work that would be as impossible to the white-collared occupant of an office stool as a demonstration of the Einstein theory would be to a Hottentot.

The trained athlete can perform wonders of physical endurance that command the admiration of the huskiest of the toilers.

Just so, the man who is accustomed to think does so with less effort and to better purpose than does the man to whom the evolution of a real idea is an occasion.

I do not mean by thinking, sitting back, opening the flood gates of the mind and letting the fancies stream through, but controlling and stimulating the mental processes to the solution of a real problem, to the effecting of a useful purpose.

What a jump there would be in human progress if all the Babbitts who are steered through life by their inherited prejudices and politics, their church, club, business and social circles, their favorite newspaper and the propagandists, would do some real thinking on their own account.

The highest function of our educational institutions is to teach men to use their minds. Somebody has wittingly remarked that you can lead a boy to college but you cannot make him think.

Using the Same Steam Three Times

STEAM generated at 250 lb. gage is exhausted from the impulse element of a 1,000-kw. turbine generator unit at 125 lb. pressure, is used to drive pumps, and is returned at 2 lb. gage pressure to the low-pressure reaction element of the turbine which exhausts to the condenser. Boilers are equipped with forced-draft chain grates, air preheaters and fin-tube side walls

SOME three years ago, when the Lincoln Oil Refining Company, of Robinson, Ill., became a subsidiary of the Ohio Oil Company, it was decided to enlarge the capacity of the refinery from 1,000 to 5,000 bbl. per day. A modern plant equipped with the latest refinements for breaking up Illinois crude oil into gasoline, kerosene and the usual byproducts, was erected on adjacent property. With fivefold demands for steam and power, former facilities naturally were inadequate. Current had been purchased, and the boiler plant that had supplied steam for seventeen years had become obsolete. A new steam plant was essential, and for comparatively small additional investment it was found that the power as well could be generated with profit. The outcome was an up-to-date coal-burning power plant of ample capacity having boilers equipped with forced-draft chain grates, air preheaters and fin-tube side walls, with condensing turbines for power generation, especially designed to bleed steam for use in refinery pumps, returning the pump exhaust to the turbine to recover the power still available above condensing pressure.

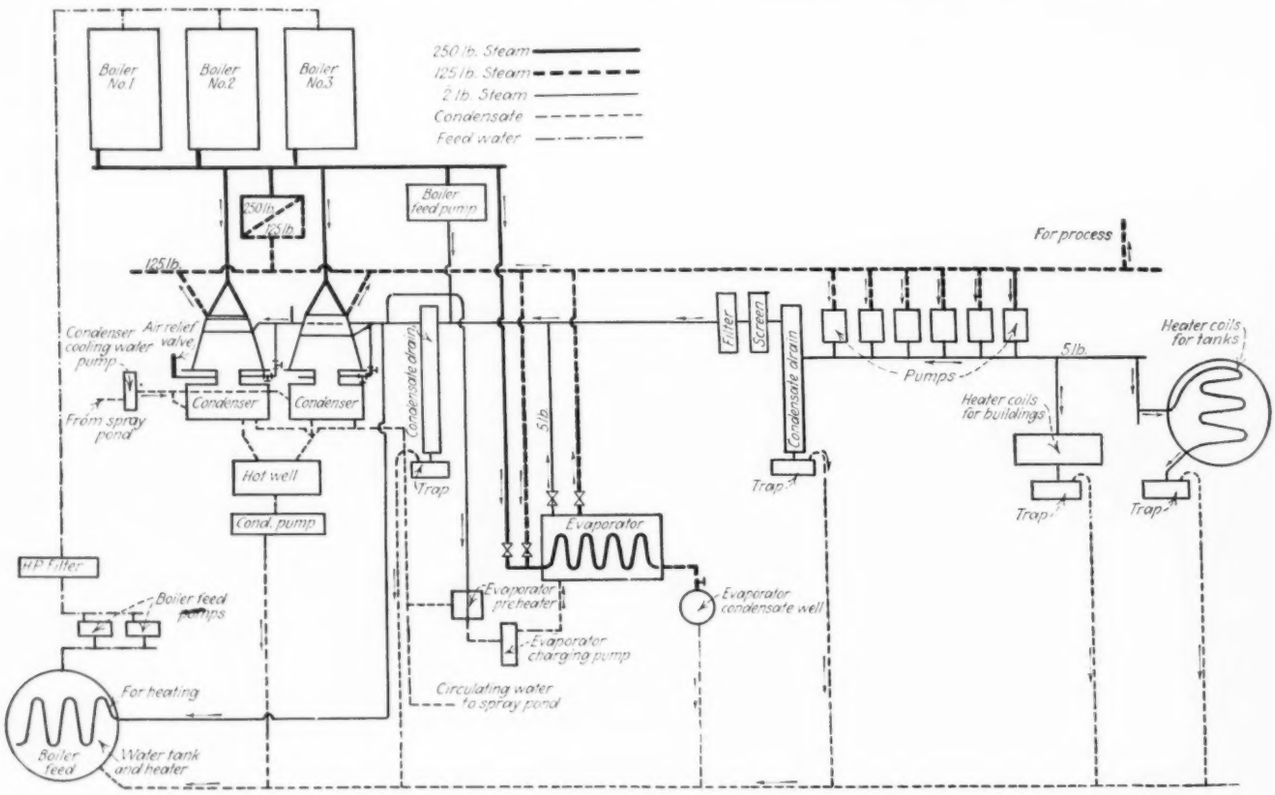


Fig. 1—Steam-flow diagram for power plant and refinery

In the older section of the refinery equipment and process had been using steam up to 125 lb. pressure. To be consistent, the new addition was equipped in a similar manner, but instead of generating and supplying steam at so low a pressure, it was decided to take advantage of the fact that a higher boiler pressure would insure a better steam rate for power generation and give an opportunity to develop power practically as a

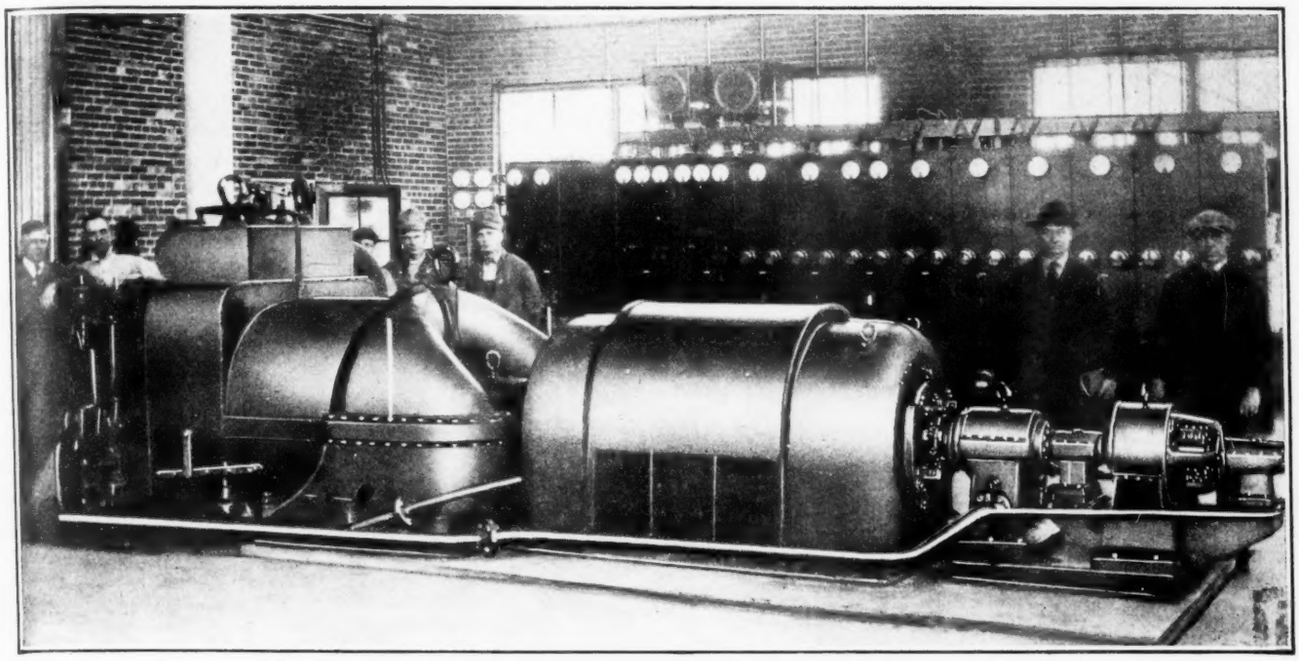


Fig. 2—One of the 1,000-kw. turbine generators and the switchboard

byproduct in expanding the steam to the refinery pressure. This could be accomplished by using a turbine designed to operate against a back pressure of 125 pounds.

Carrying the same principle a little farther, it was found that after this 125-lb. bled steam had passed to the refinery pumps and process, over 75 per cent of it was still available as uncontaminated exhaust steam at 2 lb. pressure. Part of this could be used seasonally in heating coils for tanks and buildings, and to utilize the

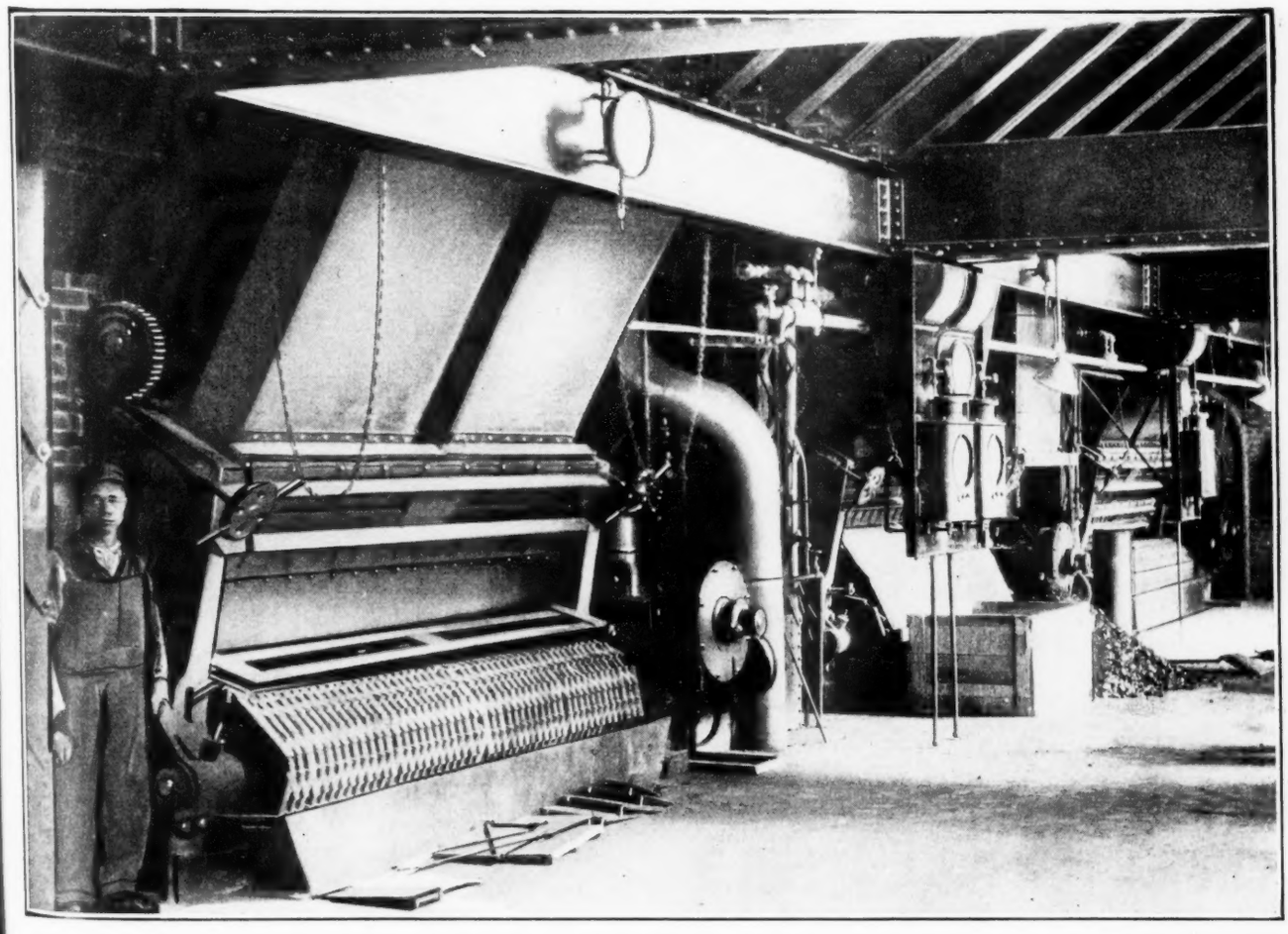


Fig. 3—General view of the boiler room

rest, the plan was conceived of bringing back all available exhaust to the turbines, where in low-pressure reaction elements, more power could be generated, with recovery of the condensate as pure feed water. This condensate, with the returns from the coils and the make-up from a single-effect evaporator, is collected in a 150,000-lb. boiler-feed tank giving a constant supply of pure water so desirable for boiler operation at high rating.

Fig. 1 shows the entire plan diagrammatically. To be conservative and to limit expenditures for valves and fittings, a pressure of 250 lb. was selected. A connected load in motors of nearly 2,000 hp. indicated that the power demand could be met by turbine generators of 1,000 kw. Two Westinghouse machines of this capacity were installed, one as a reserve for the other, with three boilers, each containing 5,260 sq.ft. of surface.

Referring to the diagram, it will be seen that 250-lb. steam is supplied to the impulse element of either turbine and exhausted into the 125-lb. main supplying steam to the refinery water and oil charging pumps and to process heating demands. A number of the pumps are provided in duplicate, one motor-driven and the other steam-driven, giving the flexibility desirable for balancing the power and steam demands. If both turbines should be out of commission, the 125-lb. main may be supplied with live steam through a reducing valve. Safety valves set to blow at 140 lb. protect this main. Steam at 250 lb. also is carried to the evaporator, but present practice is to draw from the 125-lb. main and return the vapor to the 2-lb. exhaust line carrying back all available exhaust to the reaction elements of the main turbines.

Details of the plan evolved to cover automatically a wide range of operating conditions and maintain a balance between the power and steam demands, will be better understood by reference to Fig. 4, a section through one of the turbines with a diagrammatic layout of the control equipment. Between the impulse and reaction elements there is a fixed diaphragm which forces all the steam coming from the high-pressure impulse element into the 125-lb. main, except a small amount of leakage around the shaft into the low-pressure end of the turbine. The governor controlling the admission of high-pressure steam responds to speed variations and also to variations in pressure in the extraction chamber. In other words, the governor, which is of the oil-impeller type, is controlled by two oil pressure mechanisms, one affected by speed and the other by the pressure in the extraction main. Throughout the normal range of speed the bleeder-pressure regulator is capable of overcoming the speed control on the main governor. The effect of this mechanism is to cause the governor to admit more steam to the turbine in case the bleeder pressure drops, and less steam if the pressure rises above 125 lb., so that only that quantity of steam that can be used in the bleeder line is admitted to the turbine. A hand-controlled valve *A* in a bypass line around the stationary diaphragm is provided, so that the machine may be operated straight condensing if desired. There is also a governor-controlled bypass valve *B* between the two compartments of the turbine.

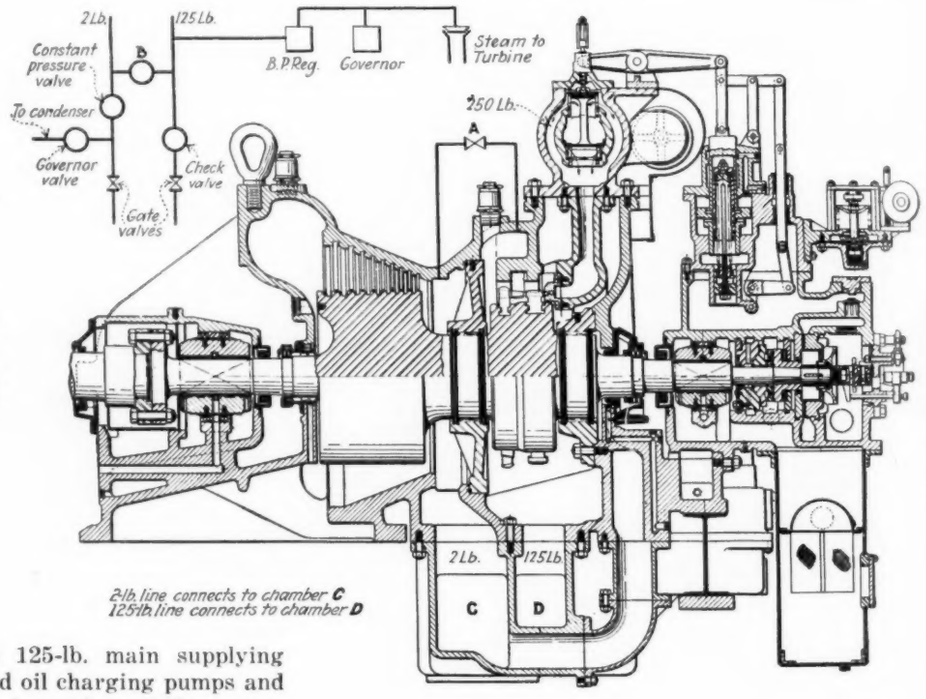


Fig. 4—Sectional view of turbine, with diagram of steam connections

In the upper left-hand corner, the diagram shows the connections to the turbine at the top, where the figures 2 lb. and 125 lb. appear. The gate-valved connections at the bottom of these vertical lines lead to and from the low-pressure steam driven pumps.

Normally, valve *B* will be closed. The speed and pressure governor will admit sufficient steam to the impulse element to maintain the 125 lb. bleeder pressure. All this steam with the exception of the leakage around the shaft will be returned, and about 75 per cent of it will pass through a constant-pressure valve into the low-pressure turbine section. The constant-pressure valve is fitted with an automatic closing device, and the return steam connection is also provided with a bypass valve to the condenser.

A separate governing mechanism responsive to speed controls the bypass valve to the condenser and the bypass valve *B* connecting the high- and low-pressure elements of the turbine. Throughout the normal range of speed the constant-pressure regulator will be capable of overcoming the speed control on the main governor and holding the 2-lb. back pressure. If the load on the machine requires less than 75 per cent of the bled steam, the speed will increase and the governing mechanism will open the bypass to the condenser and thus decrease the amount of steam re-entering the turbine. With

continuing decrease in electrical load and no change in the bleeder demand this valve will continue to open, although the main governor still remains fixed. As the bypass to the condenser opens, the constant-pressure valve closes and finally will reach a point where no steam will enter the low-pressure turbine section. At about this point the back-pressure regulating mechanism reaches the limit of its travel, so that a further increase in speed will cause a decrease in the quantity of steam supplied to the unit by the main governor, which will continue to control the speed of the unit down to no load regardless of the bleeder demand. The bleeder pressure will not be sacrificed until the low-pressure induction steam has been cut off.

Should the change occur in the opposite direction—that is, the electrical load increase—the bypass to the condenser will close and a further decrease in speed will cause bypass valve *B* to open sufficiently to provide enough steam to the low-pressure reaction element to carry the load. It will be recalled that this valve is opened under speed control and will open only when necessary in order to carry the electrical load with a small bleeder demand.

The generators on the main units deliver three-phase 60-cycle current at 440 volts, the speed of the machines being 3,600 r.p.m. Condensers are of the surface type with the auxiliaries cross-connected so that they may interchange service between units. Condensate and circulating pumps, mounted on the same shaft, are motor-driven, and the air is removed by steam-jet ejectors with inter- and after-condensers using condensate and raw water for cooling in the proportion of three to one.

Cooling water for the condensers and, in fact, all water for the refinery is drawn from wells in the gravel beds adjacent to the Wabash River, some seven miles distant. A spray pond, 200x500 ft., equipped with 300 nozzles cools the recirculated condensing water.

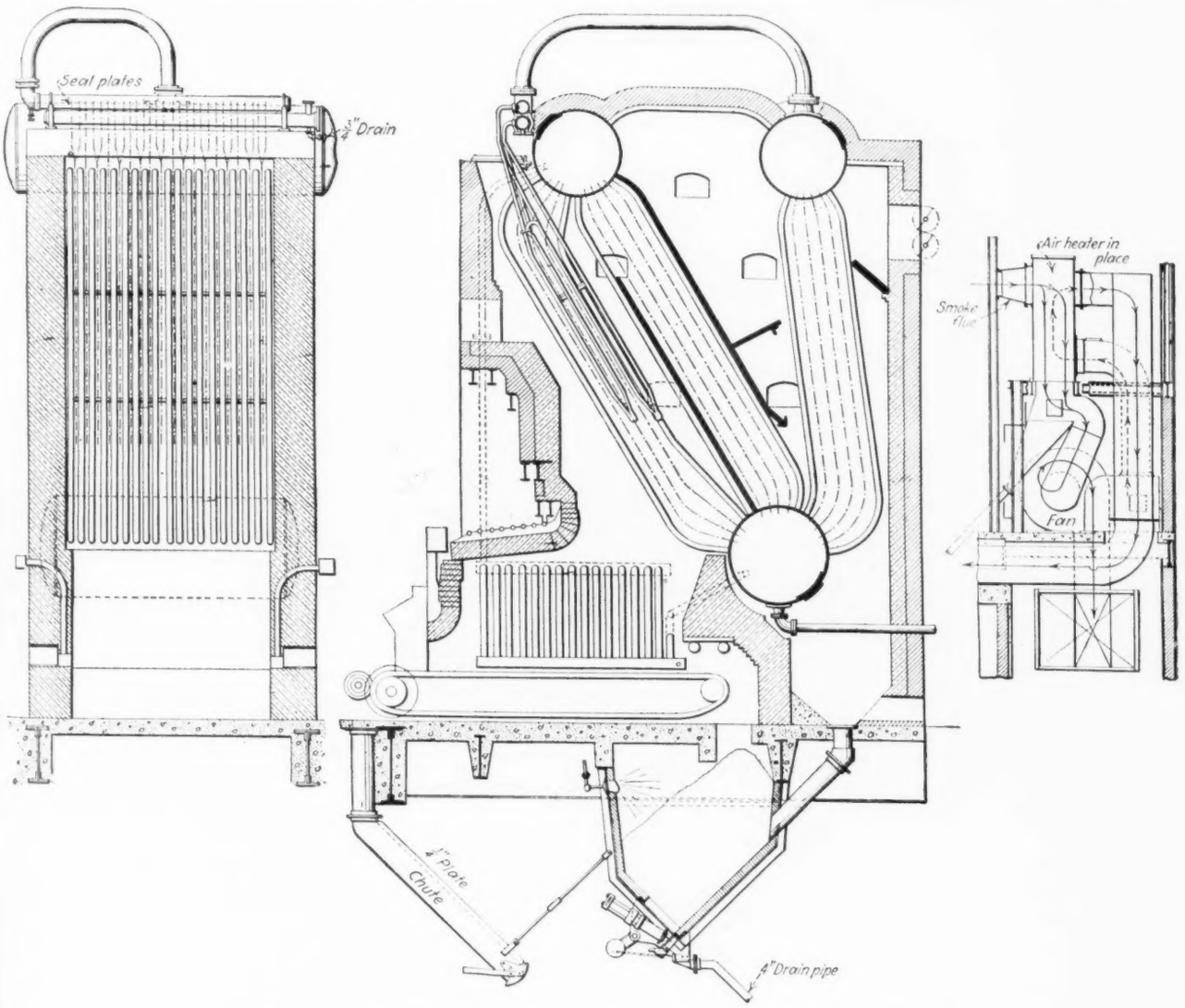


Fig. 5—Sectional elevation of a boiler and air heater installation

Conserving the heat in the steam and utilizing the supply to advantage is important, but efficient generation is the primary step toward economical production. Accordingly, a modern boiler plant was designed and equipped with the latest appurtenances conducive to efficiency, including air preheaters, water-cooled surface in the furnace, automatic combustion control and a full complement of meters to measure the coal, water and steam, the various temperatures that are required as a guide to operation and the steam supply from the plant to the various departments of the refinery.

The boilers are of the water-tube three-drum Stirling type, each containing 5,260 sq.ft. of heating surface. A convection superheater is located between the tubes in the first bank. As previously indicated, the operating pressure is 250 lb. gage and the superheat 100 deg. F. The stokers are chain grates having 108 sq.ft. of active grate area. A ventilated arch set high above the grate promotes ignition, and fin-tube surface protects the side walls under operation that will average 200 per cent of rating and the high combustion efficiency indicated by 13 per cent CO_2. In the side walls there is 80 sq.ft. of surface in fifteen 4-in. tubes per wall. The tubes are expanded into wrought-steel headers. Being on the inside, level with the fuel bed, the lower header forms a water box that will prevent clinker adhesion to the walls. Above, the tubes curve outward through the wall to connect with an upper header, external to the furnace. This surface is connected into the water circulation of the boiler, and the same is true of the water-back at the bridge wall. Cast-iron forms in the wall give access to the lower header and in both headers hand-holes opposite each tube facilitate cleaning.

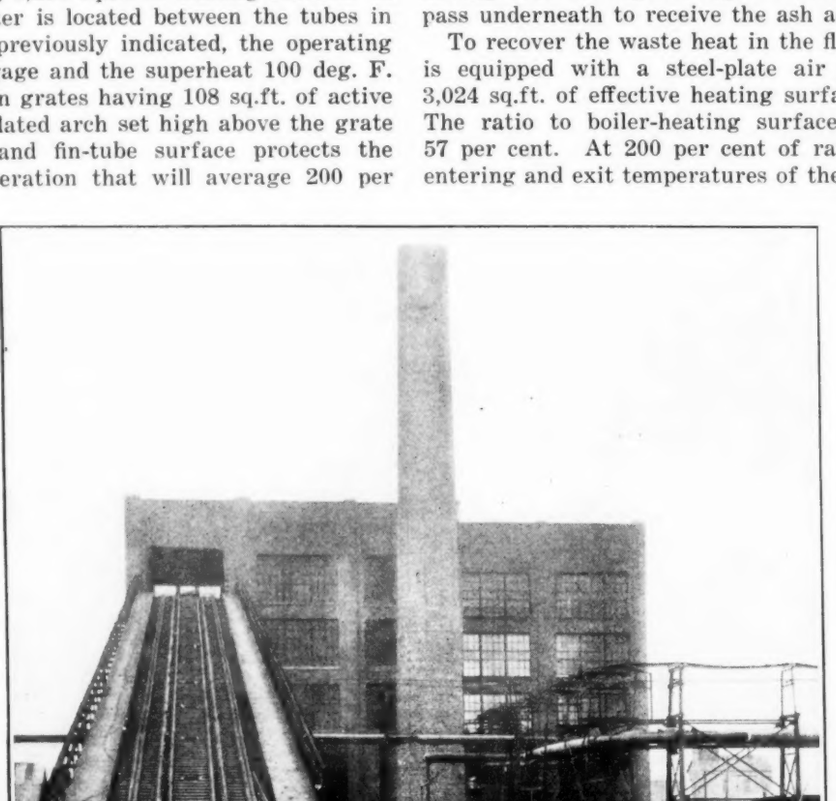


Fig. 6—General view of plant showing coal incline and overhead pipe lines leading to refinery

Fig. 7—High pressure steam header consisting of an eight-nozzle manifold

From the stokers the ashes are collected in a sealed ashpit equipped with hydraulically operated gates. Cinders from the rear combustion chamber and soot from the smoke flue after the air preheater are spouted to the ash hopper. Siftings from the grates come through the upper run of chain into the draft compartments, from which they are blown endwise by steam jets into a collecting duct at the side walls, in which additional nozzles blow the siftings to the ashpit. Clinker adhering to the grate is carried forward by the lower run of chain and at the front turn is dropped into a collecting chute leading into the ash tunnel, the boilers having been set high enough so that railway cars may pass underneath to receive the ash and the siftings.

To recover the waste heat in the flue gas, each boiler is equipped with a steel-plate air heater containing 3,024 sq.ft. of effective heating surface in 42 elements. The ratio to boiler-heating surface is approximately 57 per cent. At 200 per cent of rating the estimated entering and exit temperatures of the flue gases are 575 and 361, and of the air, 70 and 279. These figures indicate a recovery of 5.4 per cent in heat and a fuel saving of 7 per cent.

Motor-driven forced- and induced-draft fans are located on the boiler floor behind the boilers. The forced-draft fans are of the double-suction type, drawing their air from a sealed room below provided with an inlet from the turbine-room basement and several removable doors. To conserve the hot air over the boilers and to cool the space at this point, the intention is to install a connecting duct passing downward around the fan casing to the sealed suction chamber. The discharge from the fans is upward through the air heater and down to the air ducts of the stoker. The induced-draft fan draws the flue gas downward through the heater, so that the flow is counter-current, and the gas is discharged to a smoke flue below the fans, leading to a radial brick stack 110 ft. high and 8 ft. in diameter. The forced-draft fans are driven by constant speed induction motors and the induced-draft fans by variable-speed motors controlled by hand. Constant draft over the fire is maintained by a furnace regulator controlling a damper in the air supply. As a part of the combustion control system, regulators operating on varia-

tion in steam pressure, control the boiler damper position and the speed of the stoker engine.

In coal, as well as ash handling, simplicity was the feature sought. Fig. 6 shows the method, which consists of pulling the coal cars up a 25-deg. incline to a level over the storage bunker by means of a motor-driven cable hoist. To facilitate unloading, the cars should be of the bottom-dump type. Coal is measured at each stoker by a flow meter whose readings are based on the gate opening and the speed of the grate.

Eventually, from 75 to 80 per cent of the feed water will be condensate, although at the present writing the makeup is greater than 25 per cent. The present excess of makeup over the capacity of the evaporator is supplied from a water softener in the old plant. All the boiler feed is collected in a 150,000-lb. tank, which, under present load conditions, will hold three hours' supply for the boilers. To guard against waste of the pure water should the condensate come back irregularly and in excess over requirements, a 360,000-lb. outside tank has been provided to take the overflow.

Water temperatures in the smaller storage tank approximate 120 deg., the returns being heated to this temperature by the condensation from the evaporator passing through a coil and then spilling into the top of the tank. As the temperature of the feed should be at least 190 deg., plans are under way to install an additional coil in the tank drawing from the low-pressure exhaust-steam system.

In accordance with established practice in the plant, the boiler-feed pumps are in duplicate, one motor-driven and the other direct-connected to a turbine. These pumps draw their supply from the storage tank and discharge into a welded ring header with two outlets per boiler, one line feeding through a feed-water regulator while the other is a hand-controlled emergency line. Excess-pressure regulators at the pumps maintain a constant differential between the feed and boiler pressures, thus reducing the work of the water level regulators, so that the feed rate will more closely parallel the steam output. The feed is introduced into the rear upper drum and passes downward through the rear tube bank, which may be regarded as an integral economizer, as the main boiler circulation is between the upper front drum and the mud drum.

An interesting feature of the high-pressure steam piping is the special steel manifold, 12¾ in. O. D. shown in Fig. 7, to which eight nozzles are welded and, counting the ends, ten openings are provided. Four 6-in. nozzles provide an inlet for each of the three boilers and one for a future boiler. There is a 6-in. outlet to each turbine and one to the reducing valve supplying 125 lb. live steam. Two other outlets supply steam-using auxiliaries. The ends are blanked off but may be used for future connections. In general, extra-heavy steel pipe with Cranelop joints is used for the higher pressure. At all valve locations convenient grating galleries have been arranged.

Pipe lines to the refinery carrying the 125-lb. steam, the 2-lb. return steam and the condensation, as well as the electric cables, are carried overhead on steel A-frames, with the supply lines pitched away from the power house and the return and condensate lines pitched toward the power house.

For the general design and layout of the power plant, much credit is due H. L. Deming, general manager of the company who, with the assistance of R. H. Nicholson and G. W. Uzzell, supervised the entire project.

Trace of Mercury Easily Detected

As small a proportion as one part of mercury in 20,000,000 parts of the atmosphere can be measured accurately by a device that has been developed in the research laboratory of the General Electric Company; one in 8,000,000 parts can be determined quickly.

Mercury poison is accumulative; it seems to make little if any difference whether the amount of vapor is inhaled as relatively large amounts in a short period of time or as slight amounts over a period of months. Because of the increased industrial use of mercury in heating operations, in various chemical processes and in the newly developed mercury turbine, it has become important to have a method whereby leaks in apparatus and traces of mercury vapor in the atmosphere can be detected quickly.

Previous methods of determining the amount of mercury vapor in the atmosphere were tedious processes that required considerable time and the services of an expert chemist, and even then the results were usually far from accurate, especially when considering very small amounts of the substance. The new method gives quick results, does not require chemical training to carry out, and is accurate.

The principle on which the new method is based is a reaction between a solid substance, selenium sulphide, and the mercury vapor, with the reaction product a colored substance easily observable with the eye. The yellow selenium sulphide is applied as a coating on paper. The paper is blackened on exposure to air containing mercury vapor, the degree of blackening depending on the concentration of the mercury, the time of exposure and various other factors that can be definitely controlled. There seems to be practically no lower limit to the concentration that can be detected by this method.

For continuous and automatic registration of the mercury vapor there has been devised a system in which a continuous strip of the coated paper is drawn slowly over an opening through which the air flows, a small clock motor moving the strip of paper at a uniform rate. A short time after the exposure the colored strip of paper can be compared with a standard scale in which the different shades from yellow to black have been calibrated in terms of mercury concentration.

If an incandescent lamp is placed in front of the strip of paper and a photoelectric cell behind it, the amount of light reaching the cell will depend on the amount of blackening of the paper. The light can regulate the readings of an ammeter, so that the concentration of the mercury vapor can be determined either by observing the color of the paper or by reading the ammeter. It is also possible to so arrange the photoelectric cell circuit that, should the mercury concentration become dangerously high, a warning gong will be sounded. The apparatus is then an automatic chemist.

Without considering the relief of stresses that may be obtained from the tubes or stays in a boiler, for a given internal pressure per square inch the longitudinal stress, or stress at right angles to a circumferential section of the shell, is only one-half as much per unit of length as the girthwise stress per unit of length of the shell. Hence, to weaken the shell as little as possible, manhole openings are placed with their narrow dimension lengthwise of the shell.

Does the Chief Know His Business?

The Service Engineer Has Doubts About Some

By JAMES L. YATES

OCCASIONALLY, someone criticizes oil engines as a class, basing his remarks on experience with a particular engine. To establish a general theory on an isolated case is dangerous, but it must be conceded that in too many instances the operator has not been properly instructed and does have more trouble than should be the case. A recent visit to a Louisiana plant containing two six-cylinder two-stroke-cycle solid-injection Diesels may be related to illustrate this point.

Fig. 1—Ideal conditions found in No. 1 cylinder

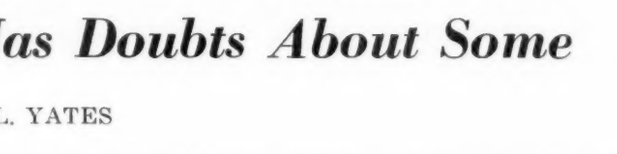


Fig. 2—This diagram shows why the bearings pounded

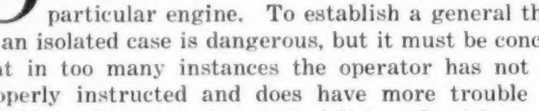


Fig. 3—Delayed combustion was revealed by this diagram

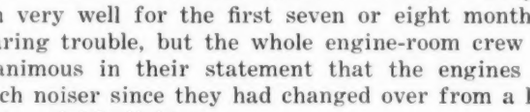


Fig. 4—The diagram used as a standard of comparison

I had but introduced myself to the chief engineer when the watch engineer left the engine he was inspecting and came over to the desk.

"Another bearing cracked through, Chief," he said.

"That's the seventh top half crankpin bearing we've broken in the last three months," remarked the Chief, "and so far we can find no reason for it."

"Have you one of the broken bearing halves that we might look at?" I asked.

"Yes, there is one over there," he replied.

Examination showed three cracks running across the face of the bearing, parallel to the pin, each crack going all the way through. Taking it over my knee, it readily broke into two pieces, with the application of a little force. The fracture thus exposed showed that the bearing had been subjected to very heavy pounding, so much, in fact, that the babbitt section between the two outside cracks could be reduced to small pieces by inserting the point of a knife blade into any of the thousand and one small cracks running all through the metal. In short, that particular bearing had been "pounded out."

"That's fine; I agree that that bearing was pounded out," said the Chief, in answer to my observations, "but what I want to know is what caused the pounding."

Not so easy, but when in doubt, ask questions.

The engines were about a year old, he explained. They had been adjusted by a factory man when first installed, but he had not used an indicator on them. They had run very well for the first seven or eight months, no bearing trouble, but the whole engine-room crew were unanimous in their statement that the engines were much noiser since they had changed over from a heavy oil to a fairly light one.

Checking up the damaged bearings with the particular cylinders they served, we found that the cylinders that were running quietly had shown no sign of bearing trouble, while the noisier ones had given trouble in proportion to the noise they made.

Then we cut the fuel off the noisiest cylinder, and the heavy pound, or knock, disappeared. We checked the load balance of the engine with respect to the various cylinders with a pyrometer, and found that the exhaust temperatures did not vary more than ten degrees.

From this we decided that the trouble came from the cylinders and that the fuel was the culprit. Our next steps were to secure a Diesel engine indicator, remove the compression relief valves and put indicator cocks in their places.

With the engines operating at full load, we took a set of diagrams, rotating the indicator drum by pulling on the indicator cord with a rapid up-and-down motion, there being no indicator gear on this engine. As the diagrams were taken, they were all carefully numbered to correspond with the various cylinders.

Remembering that No. 1 cylinder had always run quietly and had occasioned no bearing damage, we elected to analyze its diagram, which is reproduced in Fig. 1.

Starting at *A* on the atmospheric line, the compression line proceeds to *B*, the curve showing a smooth rise in pressure due to compression of the air in the

cylinder. Then from *B* to *C* burning took place at nearly constant pressure, and from *C* on the gases expanded until the ports opened and exhaust took place.

It is readily seen from this diagram that the maximum pressure was no higher than that due to compression, and inasmuch as the compression pressure rose gradually, no shock was transmitted from the cylinder to the running gear. This guarantees more or less against bearing trouble.

We found the diagram from No. 2 cylinders reproduced in Fig. 2, to be quite different. Starting at *A*, the compression line to *B* closely resembles the compression line of Fig. 1. From *B* to *C* the fuel evidently burned at constant volume; that is, it exploded instead of burning at constant pressure. In such cases the shock of the explosion is transmitted from the cylinder to the running gear, causing a loud pound, and the diagram explained the cause of the breaking of the bearing. The explosion-like combustion was due to early injection of the fuel, so that by the time the piston reached dead center the fuel had already been gasified and ignited. Such pressure waves will pound out any bearing in time, and not only that, but the cylinder and cylinder head are subjected to an excess pressure that will lessen their ability to withstand the temperature stresses.

No one would expect a bearing shell to stand up under repeated blows from a sledge hammer, but this is essentially what had been happening in No. 2 cylinder, and when one considers that the weakest section of the shell must stand these blows 250 times per minute, is it any wonder that bearing breakage resulted?

The diagrams from Nos. 3, 4 and 5 cylinders were very much like that from No. 2, and the timing had to be retarded to reduce the peaks on the diagrams and make them like No. 1 diagram.

The diagram, Fig. 3, taken from No. 6 cylinder, was different from any of the rest. The compression line to *B* agreed with the others, but from *B* to *C* there was a falling off and then a rise in pressure, due to the injection point being too late. This cylinder ran quietly, but if we had checked its performance against No. 1, we should have found that it had a higher exhaust temperature at a given load than the latter, because all the fuel had not given up its heat before the exhaust port opened.

The point of fuel injection for this cylinder had to be advanced to bring the diagram more in line with the one from No. 1 cylinder.

The fuel pumps were shimmed up or down, as the case demanded, and, as a result, all the diagrams were within the limits shown on Fig. 4.

After I had finished making the adjustments, the Chief inquired, "Why is it necessary to change the pump setting at all?"

"Well," I replied, "doesn't sound reasoning tell you that a pump will fill better and more quickly with light fuel than it will with heavy fuel; and, again, isn't it reasonable to believe that the lighter the fuel the more quickly it will burn?"

"You win," retorted the Chief, "but tell me how you know which is the compression line on the diagram."

As I explained to him, invariably the smooth line is the compression line, although I have seen some diagrams where both lines were wavy or uneven. This usually denotes a leaky spray valve, but it is a pretty safe bet to take the smooth line for the compression line on hand-pulled diagrams.

All the damaged bearings were renewed when the retiming took place, over a year and a half ago, and since then no further bearing trouble has been experienced. An indicator is now a part of the engine-room equipment, and every time a new load of fuel arrives, it is used to check up the timing.

What Do You Really Know?

ASK any well educated man the distance from the earth to the moon and a satisfactory answer will be forthcoming. But how easily is he stumped if you inquire the distance to the next mail box? The plain fact is that we are getting our education away from home.

Engineers, at any event many of them, may be able to explain Einstein's theory of relativity satisfactorily, at least to those who are unable to check the explanation, but these same engineers frequently have forgotten the details of every-day practice. The ten questions that follow cover commonplace engineering facts. Try to answer them to see just what you do know. Correct answers are given on page 748.

Ques. 1.—How can a Corliss engine be increased in speed from 82 to 110 r.p.m., the belt pull being constant?

Ques. 2—What is the water rate per kilowatt-hour to be expected from a 300-kw. turbine operating with 150-lb. steam and a 28-in. vacuum?

Ques. 3.—Does a hydrostatic lubricator feed oil into the steam pipe only when the oil drop is seen to pass up through the sight glass?

Ques. 4.—Why is it necessary to raise the pressure of ammonia in order to liquefy it?

Ques. 5.—What is the fewest number of stages possible in a centrifugal pump supplying feed water to a 300-lb. pressure boiler?

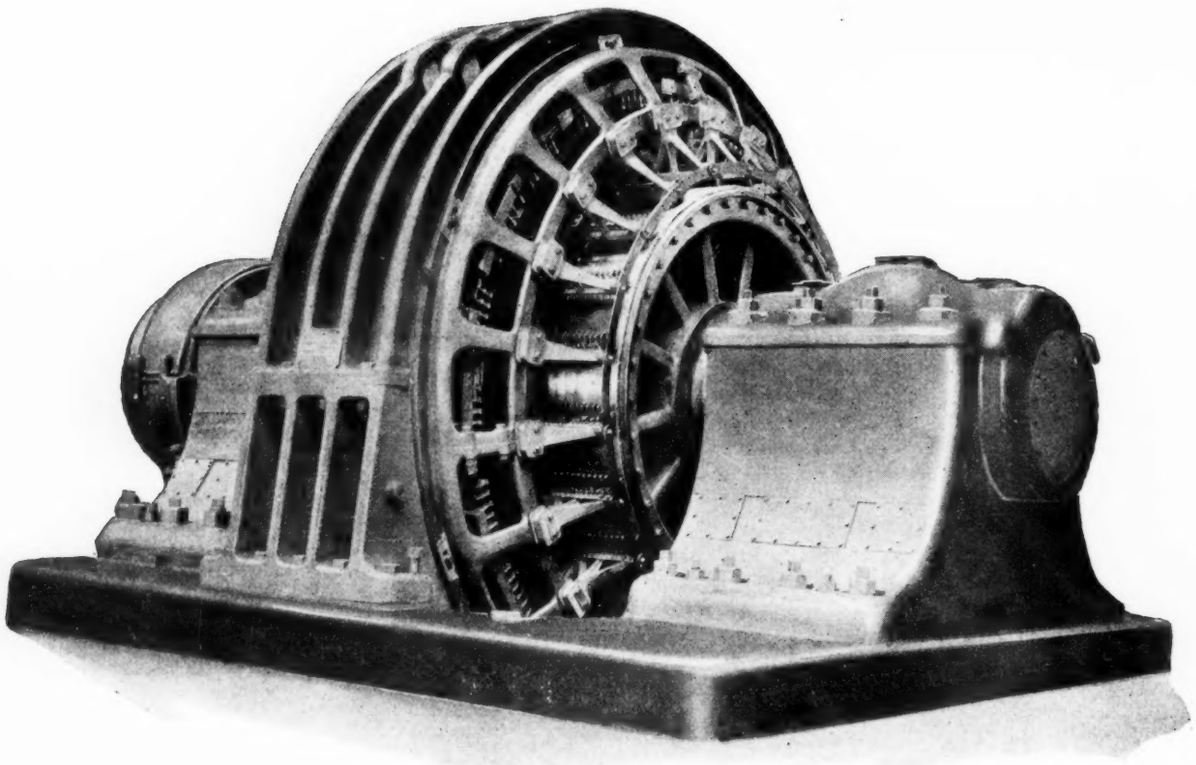
Ques. 6.—If coal costing $7.50 per ton shows 11 per cent moisture, 9 per cent ash and 13,050 B.t.u. per lb. of dry coal, how many B.t.u. are purchased for 1 cent?

Ques. 7.—Who built the first boilers for 50-lb. pressure and higher?

Ques. 8.—What is a micro-leveling elevator?

Ques. 9.—What was the original Diesel oil-engine cycle, and do present-day Diesels conform to it?

Ques. 10.—What power-plant apparatus is associated with the name of William R. Roney?



Causes, Effects and Cures of
Unequal Division of Current Among Brush Groups

By C. O. MILLS

UNEQUAL division of the current among brush groups on the commutator of direct-current machines may be due to unequal spacing of the brushes; unequal air gap around the armature; short-circuits in one or more of the shunt-field coils; on a compound machine, one or more of the series field coils have wrong polarity; unequal spacing of the main poles; brushes in the different groups not of the same grade or improperly fitted; poor brush shunts and shunt connections; absence of shunt connections; poorly designed connections between the brush-holder studs of the same polarity; jumper connections between brush-holder studs loose, oxidized or corroded; jumpers improperly soldered into the lugs; poor insulation on one or more of the brush-holder studs; or a combination of two or more of these faults, all of which may cause sparking at the commutator and brushes and excessive heating of the machine.

THOSE that are experienced in trouble shooting on electrical machinery know that every once in a while a baffling case will occur that requires a more thorough investigation than the ordinary faults. Sometimes it demands all the resources that one can call to his aid to run down the cause or causes of the fault. It is the combination of causes that is frequently the most difficult to solve. Unbalance of currents in the brushes of direct-current machines may be the cause not only of heating but also of sparking at the brushes. At first thought it might be expected that only the heavily loaded brushes would spark, but an analysis will show that the brushes taking the smaller part of the load may also spark.

The armature of a motor or generator has magnetic poles that, if the brushes are on the commutator's theoretical neutral, are midway between the main poles, as shown in Fig. 1. If the machine is assumed to be a motor, supplied by current in a direction indicated by the arrowheads, the armature will rotate in a clockwise direction. This is due to the N pole of the armature being attracted by the S main pole and repelled by the N main pole. A similar action exists between the S armature pole and the main poles, which is seen will produce a turning effort in a clockwise direction.

This action of the armature poles on the main poles also tends to distort the magnetic field from the main poles. This effect is to weaken one side of the main poles and strengthen the other as shown. Another effect that obtains at the brushes is the reversing of the current in the coils as they pass the brushes. For example, consider the coil shown in position *A* on the left-hand side of the armature; the current in it, on the outer periphery of the core, is up through the plane of

the paper. When the coil has moved to position *B*, the current in it has reversed. In the time the commutator segment is passing under the brush, the current has decreased to zero from full value, reversed and built up to full value in the opposite direction.

This reversal of the current is made in a small fraction of a second. For example, if there were 50 segments in the commutator and the armature made 600 r.p.m., there would pass a given brush $(50 \times 600) \div 60 = 500$ segments per second. In other words, a segment passes under a brush in $\frac{1}{500}$ of a second, and the current must reverse in the coil connected to it in this time. To insure complete reversal of the current in the coil in this time, the latter must be in a magnetic field to generate a voltage that will assist in reversing the current. This can be done in two ways. The first is by shifting the brushes on non-interpole machines so that the coils under commutation will be in a field of correct polarity. The second method is to use interpoles in the machine, as shown in Fig. 2.

The interpole windings are connected in series with the armature, consequently their strength varies with that of the armature. The interpole coils are designed to give their poles a strength that will neutralize the effects of the armature poles and supply a field to assist the reversing of the current in the armature coils under commutation, which has been previously referred to. With the current balanced in the armature all the armature poles will be of the same strength, as will be all

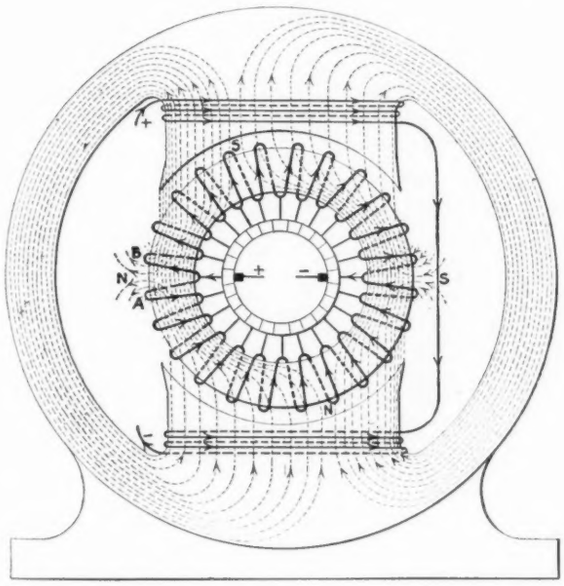


Fig. 1—Diagram of two-pole direct-current motor, showing distribution of the magnetic field

the interpoles. Therefore, if the interpoles are properly designed, they can maintain a proper commutating condition at each of the brush groups.

Where there are four or more groups of brushes on the commutator, all the positive groups are in parallel, likewise all the negative groups. It is essential to have the current divide equally among all the groups or good commutating conditions cannot be maintained and trouble from sparking at the brushes may result. For example, assume that the motor in Fig. 2 takes 50 amperes and the condition at the left-hand + group of brushes is such that 20 amperes goes into the armature at this point. Then the right-hand brush group will take 30 amperes into the armature winding. This will make the armature pole on the right stronger than that on the left. However, the interpoles remain of equal strength, since they are in series and the same current passes through all. With a 50-ampere load on the machine the interpoles are designed to compensate for a 25-ampere load at each of the brushes. If 30 amperes enters the armature on the right, the interpole over

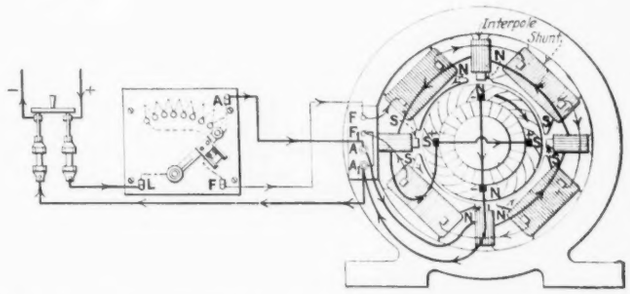


Fig. 2—Diagram of four-pole interpole motor connected to manual type starter

this point on the armature will not be of sufficient strength to compensate properly for the load. On the left only 20 amperes enters the armature, but the strength of the interpole is such that it will compensate for 25 amperes in the armature, therefore this interpole is too strong.

Under the interpole that is too strong, the current will be reversed too soon in the coil under commutation, and under the other interpole the current will not be reversed soon enough. Either condition will lead to sparking at the brushes, and there is no way to correct the trouble but to remove the cause that produced the unbalance of the current in the different groups of brushes. It will do no good to attempt to adjust the strength of the interpole winding by changing the value of the shunt across the winding's terminals. If the current is increased in this winding to make the interpole compensate for the conditions at the brush group carrying the largest current, it will aggravate the condition at the brush group that is carrying less than its share of the load, by increasing the strength of the interpole when it should be decreased. Therefore, before an attempt is made to adjust the strength of the interpoles, care should be taken to have the brushes and brush rigging in condition to obtain equal division of current.

Unequal distribution of current among brush groups may be due to: Unequal spacing of brushes; unequal air gap around the armature; short-circuits in one or more of the shunt-field coils; on a compound machine, one or more of the series coils having wrong polarity; unequal spacing of the main poles; brushes in the different groups not of the same grade or improperly fitted; poor shunts and shunt connections; absence of shunt connections; poorly designed connections between the brush-holder studs of the same polarity; jumper connections between brush-holder studs loose, oxidized or corroded; jumpers improperly soldered into the lugs; poor insulation on one or more of the brush-holder studs; or a combination of two or more of the faults. Unless these conditions are corrected, it may be difficult to set the brushes in position and adjust the interpole current to obtain sparkless commutation.

The Throttling Calorimeter Made Easy

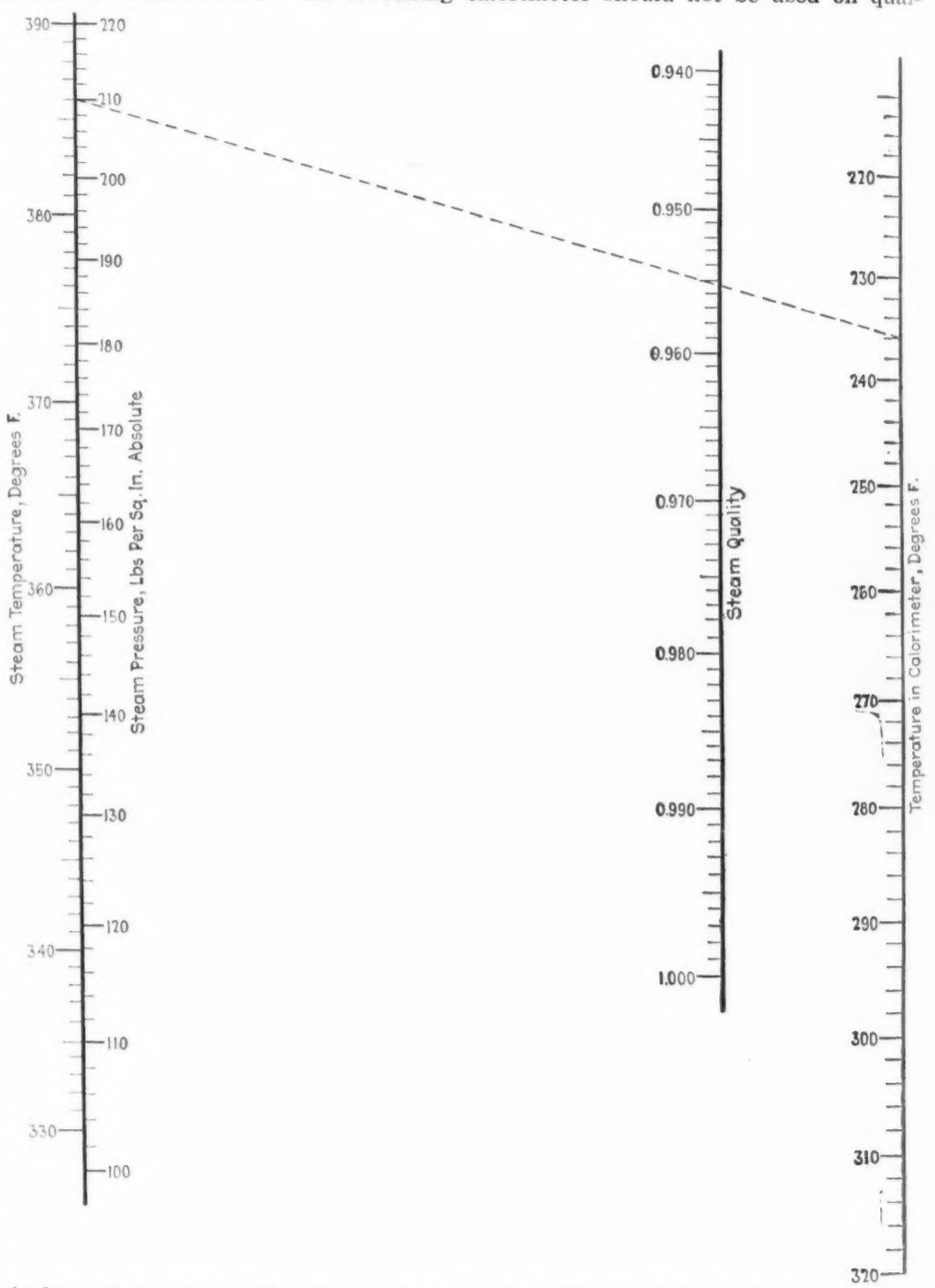
This Chart, Made by P. A. Willis,* Gives the Steam Quality Without Calculations or Steam Tables

IF THE amount of moisture is not too great, the throttling calorimeter usually offers the simplest and most accurate means of obtaining the quality of steam, and the accompanying alignment chart gives the result without calculation or reference to steam tables. Data for this chart were taken from the Marks and Davis steam tables, and it covers the range from 100 to 220 lb. per sq.in. absolute, which is believed to take care of the steam conditions met with in most plants using saturated steam.

A straight line connecting the observed values on the outer scales will intersect the inner scale at the proper quality. This line should be a scratch on the under side of a strip of celluloid or a thread stretched across the chart close to the paper. For example, if the steam pressure were 210 lb. per sq.in. absolute and the calorimeter temperature 236 deg. F., the line would take the position shown dotted in the chart, indicating a little over 0.955 quality; that is, a little less than 4.5 per cent moisture.

The scale at the left is a double scale of pressure and temperature, since in some calorimeters the steam temperature is taken while in others a pressure gage is used. This scale is also useful in itself as the pressure-temperature relations of saturated steam can be seen at a glance. The right-hand scale gives the temperature of the low-pressure superheated steam in the calorimeter, where the pressure is assumed to be atmospheric, or 14.7 lb. per sq.in. absolute. If the exhaust from the calorimeter is somewhat restricted, the pressure in the calorimeter may be slightly higher, but a back pressure of one or two inches of mercury will make no appreciable difference in the accuracy of the chart.

When the temperature in the calorimeter falls below 225 deg., the results obtained are not likely to be very reliable and a separating or electrical type of calorimeter should then be used. Thus at 100 lb. pressure the throttling calorimeter should not be used on qualities below 0.965, while at 220 lb. it will measure qualities as low as 0.948. Where the moisture content of the steam is likely to fluctuate widely, the combined throttling and separating calorimeter will usually be the best type to use.



*Assistant professor mechanical engineering, Missouri School of Mines.

Experiments with Furnace Slag Prevention

By GEORGE G. McVICKER

AFTER various methods of using salt had been tested it was found that a crucible of salt placed on a shelf within the furnace greatly reduced slag trouble on the brickwork and tubes

THE formation of slag on boiler tubes has always been a serious cause of direct loss, not only because of its insulating effect, but because slag tends to destroy metal and brickwork.

Attempts to remedy this situation have generally been along the line of removing the slag after it has accumulated and solidified, rather than preventing its formation. Slag removal generally resembles a mining operation on a small scale. Any fireman or helper who has had this work to do will tell us that it is not a job to be sought after.

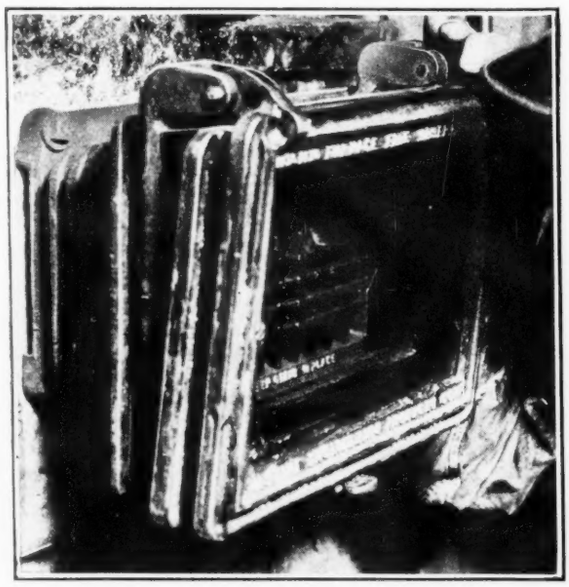


Fig. 1—Crucible can be seen and results watched through observation door

Some years ago our plant had so much trouble with slag that we changed to a better grade of fuel, although this increased operating expenses something over $3,000 a year. While there were other advantages than slag reduction, these were far from sufficient by themselves to justify the change.

More than a year ago we resolved to make some experiments with a view to reducing the formation of slag by the use of preventives. With a sufficient installation of modern instruments we were in a position to check accurately and note any change.

Our most successful experiments were made with common salt applied in various ways. In one experiment a solution of salt equivalent to sea water was fed with the fuel by keeping the slack coal wet down with it. The results were satisfactory as far as slag prevention was concerned, but the loss of heat due to the evaporation of the water was found to be too great, as it was in other attempts that were made to feed the salt in solution.

We therefore decided to use common barrel salt in the loose dry form for further experiments. Feeding the salt in the dry state with the fuel seemed the most efficient method, and we experimented with it for some time. It was, however, necessary to abandon this method of feeding for several reasons, the principal one being that the salt could not be kept properly mixed with the fuel even when fed in the chute next to the furnace. It seemed impossible to prevent the fine salt from sifting through the coal.

A suggestion that we considered but did not carry out, was that the coal be dipped or sprinkled with salt-saturated water and allowed to dry. It is reasonable to believe that good results could be obtained by this method. The suggestion would appear to be most practical where sea water is at hand, although there are certain disadvantages, the most serious one being the corrosion of the iron parts of the chutes, feeders, etc.

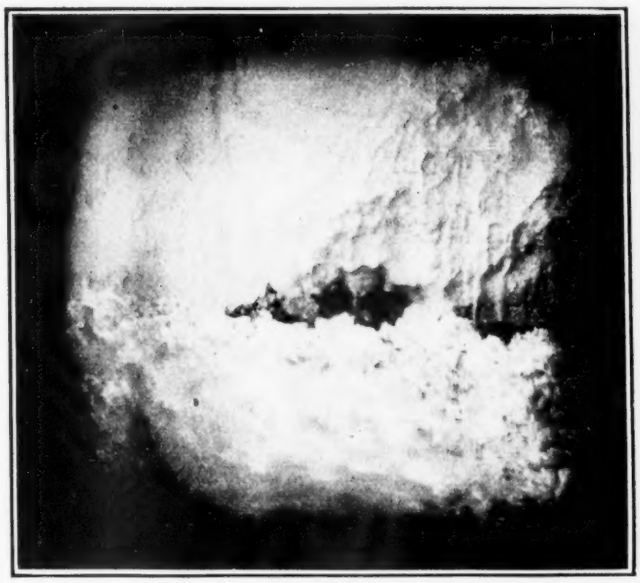


Fig. 2—Mass of slag on tube

Blowing the salt into a furnace by means of a strong air blast through a small pipe and nozzle proved effective at those places to which the salt could be forced, but we were compelled to adopt a yet simpler plan because of the large amount of air required in proportion to the quantity of salt used, the necessary arrangement for the blast, the feeding arrangement for the salt and, most important of all, the placing of the nozzle so that it would not clog with heat.

The method finally adopted probably does not give as perfect a solution of the slag problem, yet its simplicity and ability to operate without any close attention or any trouble caused its selection.

About one-third of the distance from the regular observation door at the side of the furnace, and a foot above it, another opening was cut through the wall, and to it an observation door was fitted (Fig. 1). This special door served various purposes, such as watching the effect of the preventives on slag formation, to see

Fig. 3—Effect of charge of salt on slag mass shown in Fig. 2

the position and amount of the salt and to protect the observer.

Just beneath this door on the inside of the furnace wall a shelf was formed, partly by cutting out of the wall a small alcove and partly by building out the wall from a point about two feet below the shelf. This shelf is 20 in. below the bottom of the observation door and 4 in. ahead of the door. Placed on it is a specially shaped carborundum crucible with one flat side which rests against the wall in the alcove. The rest of the crucible is circular. It is 14 in. deep inside and 3 in. thick.

On the side of the observation door opposite the crucible a deflector is constructed. This is part of the wall and built up with the same brick as the wall itself. It is 3 ft. high and extends into the furnace 16 in. Its purpose is principally to shield the crucible from the draft and part of the heat, and also to shield the door, which must be opened when new supplies of the salt are placed in the crucible.

A special ladle made from an old brass cylinder lining is used to shovel or dump the salt into the crucible. The ladle holds about 12 lb. of salt, or enough for one charge, and a charge is placed in every four hours. Lump rock salt or crushed crystals give equal results. The lump salt probably lasts somewhat longer, but its use makes the cleaning of the crucible more difficult. This has to be accomplished once a day by means of an oval-bottomed dipper with a special handle. An accumulation of cinders is the principal material to clean out.

This equipment is more effective in preventing the formation of the slag than it is in removing it after it has once collected. One experiment was made in attempting to remove a heavy mass of the accumulation by placing large quantities of the salt with the fuel. This resulted in loosening a part of the deposit, and probably would have removed most of it if the experiment had been continued, but the length of time required was found to be so great as to make the method impracticable. Figs. 2 and 3 are photographs taken through the observation door before and after the experiment respectively. Fig. 3 plainly shows the tube with the molten and partly dissolved slag dripping from it.

After a year's use of this method we are able to report that no bad results have been observed. The good effects are so pronounced that we expect to continue using this simple process until some better means of slag prevention is found.

Power Plants in Cuba

By H. C. Francis

Power plants in Cuba may be divided into two classes —central stations for power and lighting and those for sugar-mill operation. The former are now practically all owned by one company, which is linking up the transmission lines of the island, utilizing present central stations and planning for new ones. The power units comprise both reciprocating engines and turbines, with a few internal-combustion engines, mostly as auxiliaries as yet, although it is understood that one of the newer stations has Diesel engines as the complete power units. An increase in the use of Diesel engines is confidently expected as stations grow or are improved.

Boiler plants are divided between those using coal and oil for fuel. The use of oil is not increasing much at the present time, owing to the uncertainty as to future prices. There is said to be little difference as to cost at present, and one is obtained about as easily as the other.

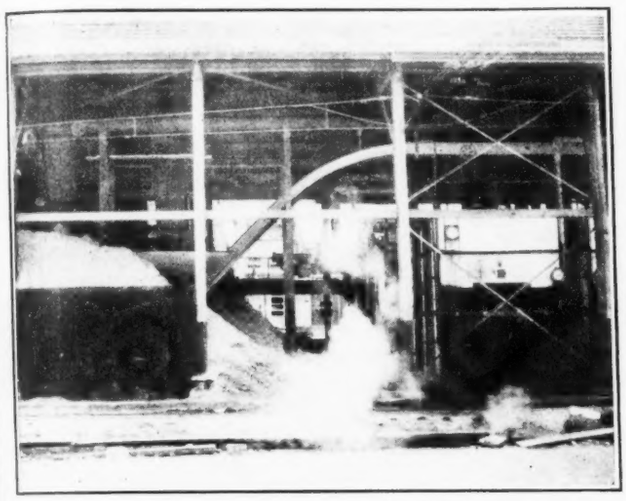
Sugar mill or "central" power plants burn bagasse, or sugar cane refuse from the mills, for the most part during the grinding season. Some mills have boilers with fireboxes that will not handle bagasse satisfactorily, and so most of the bagasse has to be carted away from the mills and burned. In most mills, however, all the bagasse is burned, usually with a small percentage of fuel oil added to counteract the moisture left by the crushing rolls. For even though the bagasse seems dry to the touch, it still contains considerable moisture.

In the modern mills the bagasse drops on a conveyor as it leaves the crushing rolls, the conveyor carrying it up to the top of the boilers when it drops onto a cross conveyor and is fed to the fireboxes of the different boilers. Very little of the bagasse is now hand-fired, as was formerly the case. The fuel oil is added just before it goes to the furnaces. According to some of the engineers bagasse makes a clinker that is hard to remove from the grate bars and that gives considerable trouble at times.

There is a tendency to use more and more electric power in the sugar mills, the rolls being driven by electric motors in some instances. This drive makes a

much neater looking mill than where the slow speed engine is used, and simplifies the boiler-room piping and similar problems. The use of the electric drive on the rolls generally means an electric generating power plant with steam turbines and the usual transmission lines. The steam-using units can, however, be placed near the boiler house, and there is no long piping to the crushing rolls as where they are driven by steam engines.

There is some talk of Diesel- or fuel-oil-driven sugar mills, but for the present at least this seems to be confined to the use of oil engines as auxiliaries, such as to supply light and power during the idle season, when the mills are not grinding. So far as can be learned, there are no mills in which the crushing rolls are driven by oil engines direct. With the growth in the use of electric-driven crusher rolls, there may come a great increase in the use of oil engines in the power houses where the current is generated. The principal consideration in sugar mills, as in most other power using units, is dependability.



Partial view of boiler room showing bagasse conveyor

Boiler Inspection in Germany

In discussing boiler legislation and explosion statistics reference is frequently made to the laws and practices of Europe. The following information regarding the German system and organizations, for which *Power* is indebted to H. Kriegsheim, president of the Permutit Company, will be interesting in this connection.

Dampfkessel Ueberwachungs Vereine

The German federal law provides (a) that the design of every steam boiler, as well as the boiler itself before it is put in operation, must be examined by an expert appointed by the government and (b) that boilers in operation must be inspected regularly by such experts. Every state in the Union can add local rules to these general federal rules, but the general federal rules must always stand. Every state, after proper examination, can also grant licenses to exercise the duties of the state engineers, to engineers in the employ of associations of steam boiler users who apply for that privilege. These associations of steam boiler users, voluntarily organized for the purpose of having their boilers inspected by their own licensed engineers, must, of course, submit to certain rules before such a privilege is granted to them by the respective states. Steam boiler users' associations in Germany, employing their own inspectors under government licenses, never were and are not today insurance companies.

Approximately 40 steam boiler inspection associations exist in the various states within the German realm. The steam boiler inspection associations in the State of Prussia are united in the *Zentral-Verband der preussischen Dampfkessel-Ueberwachungs-Vereine*, which was organized in 1884.

All the German steam boiler inspection associations, those in Prussia included, form the "General Union of the German Steam Boiler Inspection Associations." The proceedings of the General Union are published by the *Verein deutscher Ingenieure* and four of them have appeared. The proceedings of the fifth annual meeting held at Zurich, 1926, is just appearing.

The *Internationale Verband der Dampfkessel Ueberwachungs-Vereine* comprised the German inspection associations and those in France, Austria, Belgium, Italy, Sweden, Denmark, Russia and Switzerland.

Steam Boiler Owners Association—Vereinigung der Grosskesselbesitzer E. V.

The Union of Large Steam Boiler Owners has been organized in recent years for the purpose of financing research work for better and safer steam boiler operation and to represent the steam boiler owners in federal conferences relating to changes in the boiler code. It has nothing to do with the regular inspection of the boilers of its members.

The boiler code, or, as it is officially called, *Allgemeine polizeiliche Bestimmungen ueber die Anlegung von Land--Dampfkesseln, Erlass des Bundesrates auf Grund des Par. 24 der Reichs-Gewerbeordnung* and all amendments thereto were originally drafted by the federal government in co-operation with the representatives of the association of steel mills (*V.d. Eisenhuttenleute*), and of boiler manufacturers, of technical societies (*V.D.I.*) and the steam boiler inspectors. The steam boiler owners themselves not being properly organized, had little or nothing to say as a union. In order to present a more united appearance at such meetings, the owners of large boiler plants throughout Germany united and organized the Union of Large Steam Boiler Owners (the letters E.V. affixed to the name stand for *Eingetragener Verein*; that is, registered nonprofit-making society.

As far as our knowledge goes, every member of this association must operate at least 10,000 sq.ft. of boiler surface. Boiler manufacturers, of course, if they operate large boiler plants, can be, and in fact are, admitted to membership.

As stated, the Union of Large Steam Boiler Owners, for example, also provides funds for research work which is considered essential to the interest of the boiler owners. The results of the investigations of the Union of Large Steam Boiler Owners are partly issued as confidential reports and partly published. The published reports for the year 1925 are printed under the title "*Speisewasserpflege*," edited by the Union itself in 1926. The report for the year 1926 is just appearing, edited by Springer, Berlin, under the title "Safety in Steam Boiler Operation" ("*Zur Sicherheit des Dampfkesselbetriebes*").

Method of Measuring Condenser Air Leakage

USED in the Lake Shore Station of Cleveland Electric Illuminating Co. Suitable for Measuring Air or Steam. Will Show Effect of Condenser Design Changes on Proportions of Air and Steam Handled

BY C. D. ZIMMERMAN,* ELMER LINDSETH* AND C. B. ARNOLD†

LOW vacuum loss in a condenser amounts to approximately one per cent of the water rate for each tenth of an inch drop in vacuum. A low vacuum, at a given load and temperature of circulating water is due to one or more of the following causes: Insufficient cooling water; excessive air leakage; insufficient

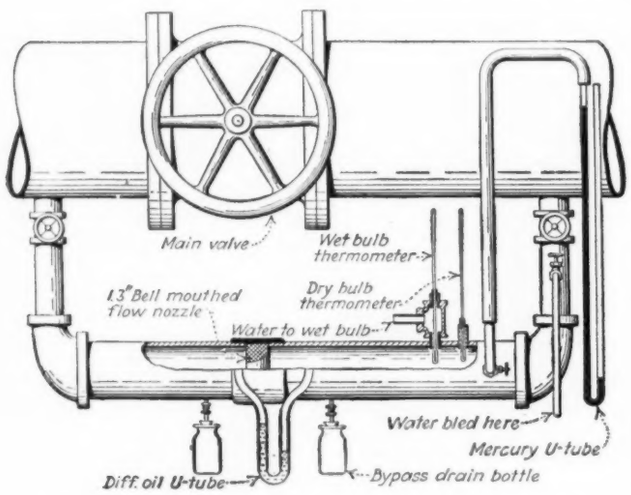


Fig. 1—Arrangement of apparatus for measuring condenser air leakage

capacity or poor operation of air removal apparatus; a dirty condenser.

The quantity of the circulating water may be determined by a heat balance, whereas a test will determine the capacity of the air-removal apparatus as well as the mechanical performance. Unless the amount of air leakage can be measured, no satisfactory way presents itself to determine whether a low vacuum is caused by a dirty condenser or excessive air leakage. No adequate basis for the comparison of condensers of unlike design exists unless the air leakage is known.

The measurement of air leakage of a unit equipped with a steam-jet air ejector is a simple problem with an orifice or other meter on the discharge. Where hurling pumps or water jets are employed, the air and water were formerly discharged into a sealed tank and the air measured as it discharged from the tank. This method involves considerable expense and is usually prohibitive for existing installations not so equipped.

During the preliminary development of a more suitable method for measuring the air leakage on a number of units equipped with hurling water pumps, the insertion of a pitot tube in the air line between the condenser and the air pump to measure the velocity head of the flow, was considered. Owing to the low velocity of the air passing through this line, a measurement of the velocity head with the ordinary U-tube would be so small as to be inaccurate. Measuring the air flow through an orifice in the main air line would be impractical from an operating point of view and would result in a low condenser vacuum if the orifice was not removed after the air had been measured.

If, however, the air is bypassed through a small flow nozzle inserted in a bypass around the main air valve, the air can then be measured under vacuum conditions. How this bypass was arranged is shown diagrammatically in Fig. 1. However, it must be remembered that under vacuum conditions air has a much greater capacity for holding water vapor than at atmospheric conditions, consequently there is a considerable amount of steam passing through the bypass. To compute accurately the volume of free air per minute handled by the pump, it is necessary to know the absolute pressure in inches of mercury, temperature of a wet and dry bulb thermometer in degrees Fahrenheit, and the differential pressure across the flow nozzle in feet of fluid measured of the mixture of air and steam in the bypass.

With these data the amount of free air leakage flowing through the bypass can be computed by applying the equation of flow through a bell-mouthed nozzle, as outlined in the A.S.M.E. Report on Fluid Meters:

$$Q_m = \frac{A_1}{\sqrt{R^4 - 1}}\, yc\, \sqrt{2gh} \qquad (1)$$

where

Q_m = Flow of air-and-steam mixture, cu.ft. sec.;
A_1 = Area of the pipe at the upstream tap, square feet;
R = Ratio of pipe diameter to nozzle diameter;
y = Compressibility factor (0.88);
h = Differential pressure across nozzle in feet of fluid measured;
c = Nozzle coefficient (0.985).

If the differential pressure across the nozzle is measured with an oil U-tube:

$$h = \frac{d_o h_o}{d \times 12} \qquad (2)$$

where

d_o = Density of the oil;
d = Density of the mixture of air and steam;
h_o = Differential of oil in inches.

*Cleveland Electric Illuminating Company.
†Brooklyn Edison Company.

The density of a mixture of gases d such as steam and air, according to Dalton's Law of gas mixtures, is equal to the density of the air at its partial pressure and temperature, plus the density of the steam at its partial pressure, temperature and quality. The quality of the steam is assumed to be unity for the reason that, owing to the nature of the conditions and apparatus, excess moisture is separated from the mixture, as in the steam separator, and is drained out of the bottom of the bypass.

When the temperature of the wet and dry bulb thermometers is the same, the air is saturated with water vapor, or has 100 per cent humidity, which is no more than a mixture of air and saturated or nearly saturated steam. Under these conditions the partial pressure of the steam is that which corresponds to the temperature of the mixture. In the event that the wet bulb reads lower than the dry bulb thermometer, a superheated condition of the steam is indicated. It is then necessary to bleed a very small quantity of water into the

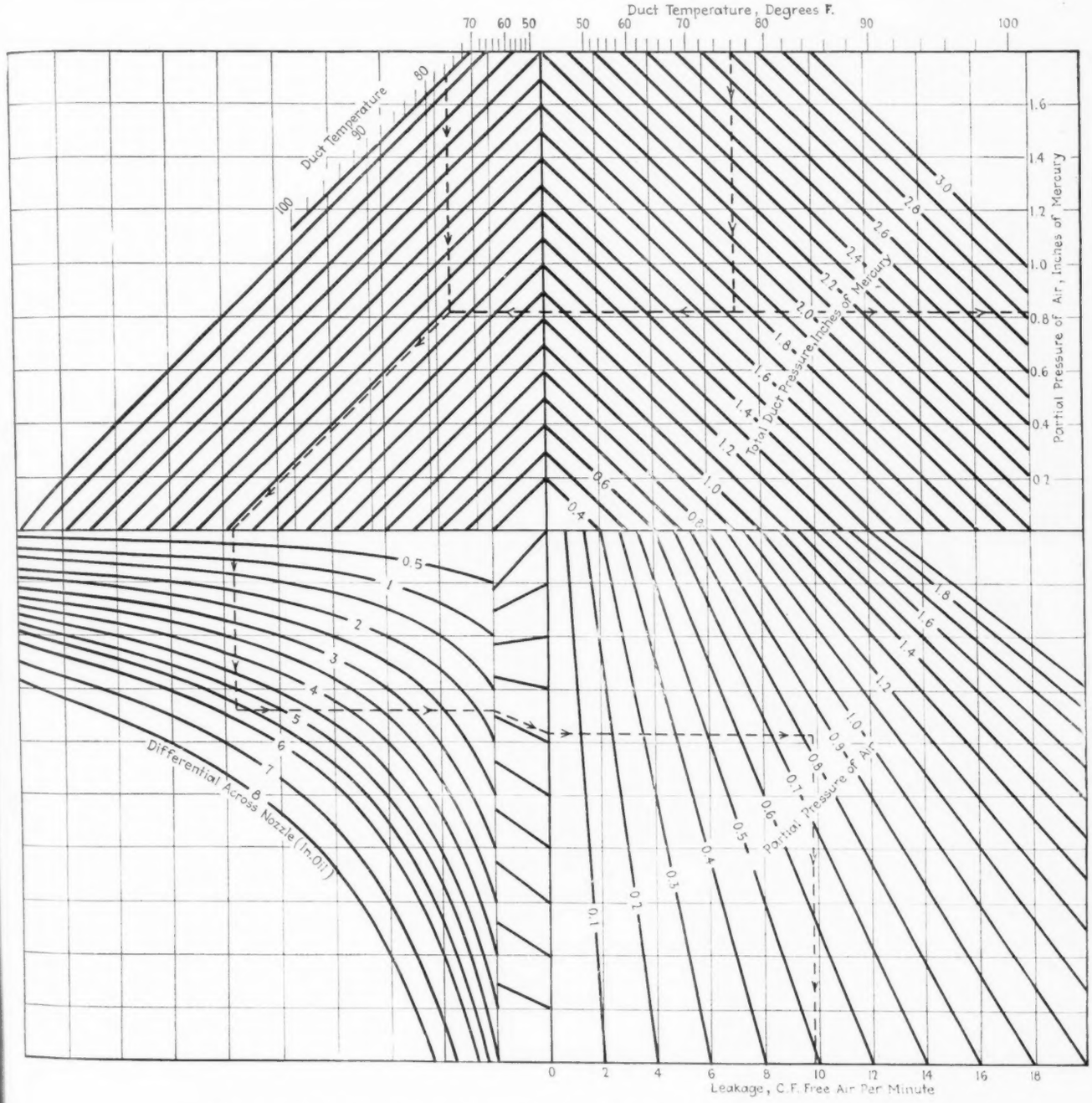

Duct Temperature, Degrees F.
70 60 50
50 60 70 80 90 100
Duct Temperature
80 90 100
Total Duct Pressure, Inches of Mercury
Partial Pressure of Air, Inches of Mercury
Differential Across Nozzle (In. Oil)
Partial Pressure of Air
Leakage, C.F. Free Air Per Minute
0 2 4 6 8 10 12 14 16 18

Fig. 2—Diagram for the determination of air leakage into condensers

Air sent through 3.1 in. bypass duct containing 1.3 in. bell-mouthed nozzle.
Based on equations and data from paragraph B_2, Appendix B. Part 1 of A.S.M.E. Research Report on Fluid Meters (1924).

$$Q = 8.55 \sqrt{\frac{h_o}{d}} \frac{p_a}{b}$$

Where Q is air leakage in cu.ft. of free air per minute;
h_o is differential head in inches of oil (sp. gr. 0.9);
d is density of the mixture at bypass conditions;
p_a is partial pressure of air in inches of mercury;
b is barometric pressure in inches of mercury.

Diagram based on 30 in. barometer, empirical compressibility factor of 0.888, air densities at 75 deg. F. and gage oil specific gravity of 0.9.

For barometric pressures other than 30 in. multiply diagram result by $\frac{b}{30}$

duct, which serves the purpose of saturating the steam, and the wet and dry bulb thermometers are found to read alike.

The partial pressure of the air is equal to the total pressure in the bypass minus the partial pressure of the steam. The density of the air and of the steam may be readily computed, the sum of which is equal to the density of the mixture d.

Solving the aforementioned flow-nozzle equation, Q_m is equal to the flow of the mixture of air and steam in cubic feet per second at vacuum conditions. The equivalent quantity of free air flowing through the bypass in cubic feet per minute is obtained from equation (5) derived as follows:

$$60 \times \frac{P_a V_1}{T_1} = \frac{bQ}{T_2} \qquad (3)$$

where

P_a = The partial pressure of air, inches of mercury;
b = Barometric pressure, inches of mercury;
T_1 = Temperature of the mixture, deg. F. absolute;
T_2 = Temperature of atmosphere, deg. F. absolute;
V_1 = Quantity of air at vacuum conditions, cu.ft. per sec.;
Q = Quantity of free air, cu.ft. per min.

From Dalton's Law the volume of a gas in a mixture of gases is equal to the volume the gas would occupy if it existed in the container alone, at its own partial pressure, hence

$$Q_m = V_1 \qquad (4)$$

and

$$Q = \frac{60 P_a Q_m T_2}{b T_1} \qquad (5)$$

The accompanying graph shows a graphical solution for the problem, which simplifies its computation materially. As may be seen from the graphical solution, extreme care should be taken in reading the temperatures and vacua from which the absolute pressures of the gases are obtained. For this reason it is advised that a mercury U-tube be used in preference to a vacuum column, thereby eliminating the error due to capillarity of a vacuum column.

Measuring the air leakage in this manner results in a vacuum drop in the condenser of 0.3 to 1.5 in. of mercury, depending on the amount of air leakage and the size of the flow nozzle used. However, it is necessary for this condition to exist for only fifteen minutes or so.

This method of measuring the air leakage is advantageous from several viewpoints. It may be used on either new or old installations, and its cost is insignificant. The apparatus may be used for measuring both air and steam, where other methods measure the air only. It has been used at the Lake Shore Station of the Cleveland Electric Illuminating Co. primarily as a routine check, but may also be used to show the net effects of changes in condenser design on the proportions of air and steam handled.

THE BEST OIL-ENGINE BEARING METAL is one that is hard enough to resist wear and tough enough to withstand the shock of service, and the latter characteristic appears to be sacrificed sometimes in order to obtain the former although the latter is more important.

A Check on Your Answers*

Ans. 1.—If the belt tension is to be constant, the cutoff must also be held constant, which requires the governor to operate at the same height as before. Usually if an engine speeds up momentarily, the governor balls move to a higher plane and the cutoff is shortened. To permit the higher speed at the original governor level, the governor pulley must be increased in diameter 110/82 or the engine shaft pulley reduced 82/100.

Ans. 2.—The rate will be between 18 and 24 lb. per kilowatt-hour.

Ans. 3.—The oil is being fed constantly from the time the drop starts to form, for it displaces water in the glass which in turn continues to displace some of the oil already in the nozzle.

Ans. 4.—It is necessary to raise the pressure of ammonia gas so that the condensing temperature is above the temperature of the cooling water.

Ans. 5.—Single-stage pumps are built for pressures as high as 300 lb.

Ans. 6.—with 11 per cent moisture, the B.t.u. per pound of coal as received is

$$13{,}050 \times \frac{100 - 11}{100} = 11{,}614$$

At $7.50 per ton, for 1 cent,

$$\frac{11{,}614 \times 2{,}000}{750} = 30{,}970 \text{ B.t.u. would be purchased.}$$

Ans. 7.—Richard Trevithick, an English engineer, invented the first so-called "high-pressure" boiler.

Ans. 8.—The micro-leveling machine is designed to stop the car on a level with the floor and keep it there. The elevator machine itself usually consists of two machines—the main machine, which is under the control of the operator from the car switch, and the micro machine, which is connected to the main machine through the brake on the latter. When stopping at a floor, the operator centers the car switch within 12 to 18 in. of the floor, and a cam in the hoistway closes a switch on the car that automatically cuts the micro machine into operation and brings the car level with the floor.

Ans. 9.—Owing to failure of his first experimental engine, which exploded, Diesel abandoned the Carnot cycle, and attempted to secure constant-pressure combustion. But the modern Diesel engine does not even follow this cycle as combustion takes place with gradual drop in pressure.

Ans. 10.—The inclined-grate stoker.

NEW ALLOYS ARE BEING USED for soot-blower elements located in abnormally hot positions in the boiler, which up to this time have either been without soot-blower elements because of the intense heat or have been protected by barriers. This is one of the outstanding developments in the art. At temperatures higher than any encountered in the hottest locations in a boiler setting, the best of these alloys are practically unburnable. They resist satisfactorily the erosive and corrosive action of the boiler gases and the constituents of the ash. Under service conditions it is found that these elements remain straight and readily operative. They so meet all demands as to constitute the practically ideal element.

*The questions will be found on page 739.

The International Economic Conference

GENEVA, Switzerland, is the scene of a meeting of governmental representatives from many countries of Europe and from the United States, to discuss economic and industrial problems, particularly those of Europe. The American delegation is made up of men of outstanding competence, and they have gone into the meetings to give freely of our experience and assistance as the European delegates wish it, but not to tell them what to do.

The whole world can be made more prosperous without detracting from the prosperity of any one nation. All must work together in this friendly competition for the success of all. America must stand behind her delegates in sincere desire to see Europe restored to full industrial vigor.

The subject-matter of this conference concerns itself with tariffs and trade agreements and international credit and many other things that seem remote from the engineer in his power plant, and technically they are remote. In a deeper sense, however, these things are vital to every man whose earning power depends upon the well-being of industry. He may not understand them any more than the user of electric power understands the generation and use of steam, but he should at least know that something is going on. And he might bestir himself to achieve a grasp of economic fundamentals. It is by such struggles that men grow in knowledge and strength.

Bleeding Old Steam Turbines

STEAM turbines ranging up to thirty thousand kilowatts in size were installed in some of our older steam stations before the advantages resulting from the use of the regenerative cycle were fully appreciated. The question naturally arises whether it would pay to improve these stations now by attempting to fit bleeders to these older turbines. This will prove to be an individual problem for every plant. One such station has already undergone such transformation with appreciable gains in operating efficiency, and many others could probably afford to do likewise.

The thermal gains from bleeding have been fully discussed in various papers and are now fairly well understood. These gains must be capitalized against the costs of making the changes.

Feed water is generally heated in these older plants by exhaust from steam-driven auxiliaries. If bled steam is to be used for feed-water heating, these auxiliaries must be replaced with motor-driven units if they cannot be converted for motor drive. It may not be advisable to replace certain of these units while dual drives may be provided on other units. Besides the direct gain due to higher economy, there will also be a gain due to decrease of unaccounted-for losses when these steam-driven units are replaced.

Many of the older turbines have excess steam capacity in the high-pressure ends or can easily be renozzled to provide this capacity. Hence it should be possible to bleed sufficient steam to heat feed water without affecting the electrical output of the unit. It is generally possible for the turbine manufacturer to advise the user at what points the casing may be drilled for bleeding sufficient steam for the purpose desired. New bleeder heaters and piping would of course have to be purchased and installed.

Feed-water temperatures in these older stations are generally in the neighborhood of 212 deg. F. When economizers are not used, it may be desirable to feed at a much higher temperature, say 275 or 300 deg. F. This higher temperature can be secured without changing the present auxiliary arrangement by attaching a new high-pressure bleeder heater to the old turbine at a point that will give the desired temperature and passing the feed-pump discharge through this heater.

These suggestions indicate certain of the possibilities of improving these older turbine stations.

Performance Data

ENGINEERS responsible for the operation of industrial power plants are always keen to acquire performance data of other plants that may be useful for comparative purposes. Unfortunately, there is little uniformity in the keeping of such records, because of the many diversified factors entering the industrial power problems and the lack of any prescribed rules or code.

Moreover, managements are generally concerned only with the cost of power per unit of production. This serves a useful purpose for the individual plant in comparing one period with another, but at that it is dependent upon certain factors outside the control of the power engineer. Such data are practically useless to plants in other industries.

The ideal setting for maintaining intelligible records is where the boiler plant is run as a production unit with all quantities measured and each department as well as the prime movers, charged for the steam used. To do this requires that various services be metered.

There are few plants, however, that are not able to determine with a reasonable degree of accuracy the cost of producing a thousand pounds of steam. Inasmuch as the greatest attention is now being focused on improvements in boiler-room practice, the cost of steam generation may be taken not only as the starting point, but as the most important item in collecting performance data for comparative purposes. *Power* will be glad to serve as the medium for the exchange of such data among its readers.

Reliability of Hydro-Electric Equipment

WATER-POWER units, taken as a group, show a high degree of reliability, notwithstanding the conditions under which they frequently operate. Such units have run more than thirty months continuously without being shut down, even for inspection. This could hardly be considered good operating practice, but it shows what hydro-electric units may do if the necessity arises. Against this enviable record there are others that are anything but reassuring to an operating engineer. When all the buckets come off a runner and go down the draft tube, little can be done to get the machine back into service except to put on a new runner. If this has to be built, the unit must be out of service for a considerable period. Fortunately, such occurrences are the exception and not the rule, but they are possibilities that must be provided for in the continuity of a power supply.

A recent report of the Hydraulic Power Committee of the National Electric Light Association showed that the average outage time, when in demand, for forty-three large units, was less than two per cent of the total time during the year 1925. These figures are probably representative, as similar records for 1924 show even better performance. The two largest hydraulic items of outage in these records are attributed to the penstocks and the runners. Of the total time that the units were out of service owing to trouble in the hydraulic system, nearly sixty per cent is chargeable to the runners and penstocks. Over forty per cent of the outage time due to hydraulic causes is chargeable to the runners alone. Another large item of outage is for causes in the electrical equipment, which accounts for about one-third of the outage time from all causes. Of this about fifty per cent is chargeable to the stator of the machines.

If the reliability of these units is to be improved, the greatest possibilities are apparently in the penstocks, waterwheel runners and the generator's stator. If a penstock is properly designed, installed and operated, there is little reason for trouble from this source. There have been a number of serious failures of this kind during the last few years, and no doubt these experiences will have a healthy effect toward improving the reliability of this part of high-head water-power plants.

With waterwheels the reliability of the equipment is not altogether a matter of design and operation, since these parts are subjected to a wide variety of conditions over which the designers and operators have no control. In some installations the water is highly corrosive or erosive, owing to an acid content or to sand and silt carried in suspension. Then, during the winter months in northern climates, it may be necessary to raise the racks and let ice and any other material carried with it go through the turbine, in order to keep the plant in operation. Although such practices may give continuity of service, they do not in general redound to the reliability of the waterwheel runners. However, all failures of waterwheel runners are not attributable to operating conditions.

Failures of penstocks, waterwheel runners or generator windings are expensive, not only on account of the large cost of repairs, but also because of the revenue loss generally associated with having a large unit out of service for a long period. Therefore there is a double incentive to eliminate the causes for long interruptions, and past experience has shown that they are in general due to causes that can be controlled.

More Power From the Same Steam

THE leading article in this issue is a splendid example of what can be done to increase the power output of a plant where there is no way of using additional exhaust steam. There must be many plants in which this plan or some modification of it would serve well.

If exhaust steam from an existing low-pressure installation system can be used, then the installation of a high-pressure turbine exhausting into the steam header of the existing low-pressure system will develop added power with no increase in the quantity of exhaust steam and, with suitable attention to the details of design, with no material change in the quality of that steam. Again, if exhaust is not utilized for heating, a low-pressure turbine might receive the exhaust from the present system and expand it to condenser pressure, with the double advantage of generating added power and recovering the condensate as distilled water for boiler feed. If the demand for added power is sufficient, the plan of the article may be used as a whole; that is, generating the steam in new higher-pressure boilers and generating added power both above and below the pressure range of the present outfit.

The turbine designer has worked out the necessary details of turbines and governors so that almost anything can be done with units of special layout, and in many instances these machines can be made up of more or less standard elements, so that the cost need not be excessive.

The operating engineer who is up against a difficult problem of changing steam and power demands, should be alive to these possibilities. They may not only save the plant by adapting it to new requirements, but also improve its efficiency and thus save the owner a tidy item of expense.

THE LENGTH OF TIME ELEVATOR CABLES have been in use does not tell the whole story of their service. What is required is a car-mileage record. The small cost of devices for obtaining these records leaves little excuse for not using them more generally. Cable costs are a large item of expense in the operation of elevators, and the wide-awake operating engineer can do much to keep down these costs by a careful study of the mileage service obtained from this part of the equipment, and the factors that influence this service. The cables also warrant careful attention, since conditions are important factors in safe operation.

EXPERIENCE WITH THE MERCURY BOILER indicates that through exercise of proper precautions and supervision there is no greater danger to personnel than in the boiler room of a high-pressure steam plant. With the safety features well in hand and a ten-thousand kilowatt unit going into commercial operation attention will be directed toward meeting other factors peculiar to the process. One of these is the ability of mercury to permeate the interstices of the surrounding steel.

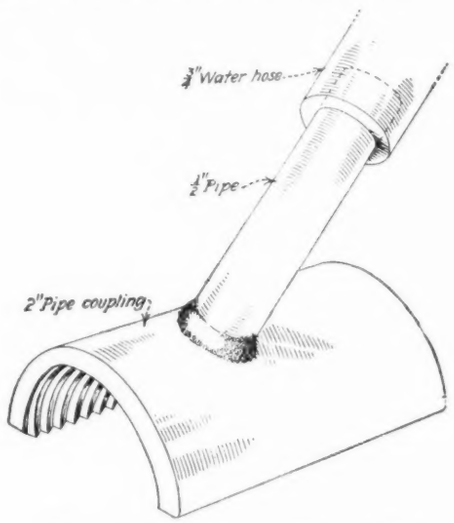
THE DIESEL ENGINE FOR LOCOMOTIVE SERVICE appears to be making substantial headway in this country. No less than fifteen railroads now have such units in operation, and four others have similar equipment on order. These are practically all of the Diesel-electric type and range from three hundred to seven hundred and fifty horsepower.

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Atmospheric Condenser Tube Cleaner

Having several hundred feet of 2-in. atmospheric condensers to clean and no available cleaner at hand, we made the device shown in the illustration. A 2-in. pipe coupling was sawed in half lengthwise, and one-half was spread just enough to fit over the outside of a 2-in. pipe. Then a ½-in. hole was drilled in the center



Cleaner made from pipe coupling

and a short length of ½-in. pipe was welded over it as shown. This short piece of pipe served for a handle and to admit water pressure to the cleaner. A ¾-in. water hose was slipped over the pipe and pressure turned on. The threads in the coupling served as teeth to loosen the scale, while the water washed the scale away.

Holtville, Calif. H. T. MILLER.

Wrong Polarity of Field Coils Causes Fuses to Blow

Notwithstanding all that has been published on testing the polarity of the series- and shunt-field coils of compound motors, the windings are frequently connected wrong. Even when trouble develops in such motors, the polarity of the field coils may be ignored for a long time before someone thinks about testing them.

In one case a 110-volt 200-ampere compound generator was taken to a boiler room and used as a motor to drive a forced-draft fan. Whenever the fan was operated at full load, the motor gave trouble by blowing the fuses at frequent intervals and caused considerable inconvenience in operating the boilers.

This trouble continued for months, until I suggested testing the polarity of the series- and shunt-field coils. The test was made by taking the belt off the motor pulley to disconnect it from the fan. The shunt-field circuit was opened by disconnecting it at the starting box, as at *F* in Fig. 1. After the shunt-field connection was opened the line switch was closed and the starting-box arm moved to the second point, when the motor started as a series machine, but ran in the opposite direction from that in which it had been operating as a compound motor. This showed that the series-field winding's polarity opposed that of the shunt winding, giving a relation between these windings similar to that shown by the arrows in Fig. 1. If the starting-box arm was moved to the on position, the circuits would be as indicated by the arrowheads, which shows that the current flows through the series- and shunt-field coils in opposite directions.

To correct this trouble the external connections to the series-field coils were interchanged. This is shown by a comparison of Fig. 2 with Fig. 1, where the external leads on terminals *S* and S_1 are connected the

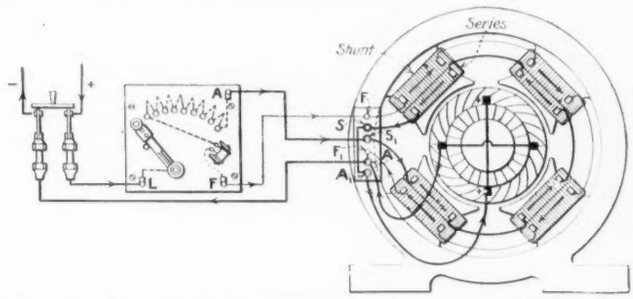


Fig. 1—Diagram of compound-motor connections with shunt- and series-field coils in opposition

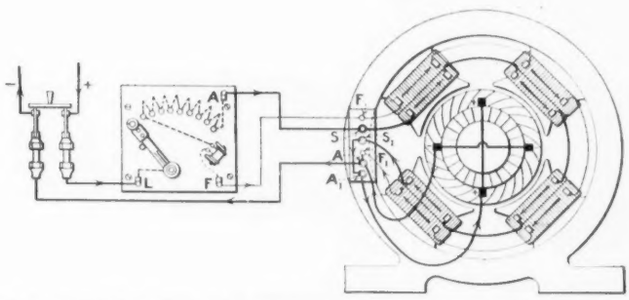


Fig. 2—Diagram of compound-motor connections with shunt- and series-field coils of the same polarity

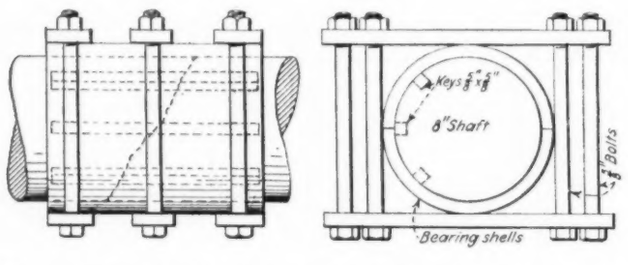
reverse in one figure from that in the other. The connection in Fig. 2 shows the relation that obtained after changing the connections. In this figure, if the starting-box arm is placed in the on position the flow of the current will be as indicated by the arrows, which shows that the direction is the same in both the shunt- and series-field coils. This change cured the trouble and resulted in a more satisfactory operation of the motor in general. T. H. REARDON.

Pittsfield, Mass.

How a Lineshaft Was Repaired in an Emergency

A main lineshaft 8 in. in diameter was found to be cracked diagonally across its diameter and about halfway through, the crack being about two feet from a main bearing. As it would involve considerable delay and expense to replace the shaft, an emergency repair was decided on.

A portable electric drill was obtained and the shaft was slot drilled to make three keyways 8 in. long, extending 4 in. on each side of the crack. The slots were afterward cleaned out with a chisel to make a



Keys were placed in the shaft and bearing shells were used for a clamp

rough keyway ⅜ in. wide by ⅝ in. deep. As there was insufficient time to fit the keys properly, they were made a rough fit in the keyways and were embedded in Smooth-on cement. After being allowed to dry for a short time, the keys were filed down to the contour of the shaft and smoothed up with emery paper. Two bearing shells such as were used in the main bearings were then obtained. These served as a clamp over the shaft and were held in place by bars and bolts as shown in the illustration, two bolts being used at each end of the bars. This repair was of course kept under strict observation, but it gave satisfactory running until a new shaft could be obtained about four weeks later. Although it might have lasted for several months or possibly indefinitely, it was thought best to replace the shaft with a new one to avoid further interruption.

Shefford, Bedfordshire, England. W. E. WARNER.

Low-Resistance End Rings Caused Squirrel-Cage Motor Trouble

In these days when the rotor windings of the older type of squirrel-cage induction motors are frequently rebuilt, a word of warning may be in order. On many of these motors the end rings are made of an alloy that has a considerably higher resistance than copper. If such alloy rings are replaced with copper of the same cross-section, difficulty may be experienced when starting the motor. The starting torque and current of a squirrel-cage type motor is a function of the rotor resistance. Increasing the resistance of the rotor winding increases the starting torque and reduces the starting current. Conversely, decreasing the resistance of the rotor winding decreases the starting torque and increases the starting current.

One case in mind is that where the end rings and bars were in bad shape, due to some of the bars being broken and others making poor connection to the end rings. It was decided to renew the winding and weld the end rings to the bars. The correct size of copper stock was available for the bars, but the material for the end rings was not and copper was used. When the motor was put into service again, it was found to take an excessively large starting current and develop a low starting torque. After trying various plans to locate the fault, an engineer from the motor manufacturer was called in on the job, who found the trouble was due to using copper end rings of the same cross-section as the alloy ones. Cutting the cross-section of the end ring in half remedied the trouble.

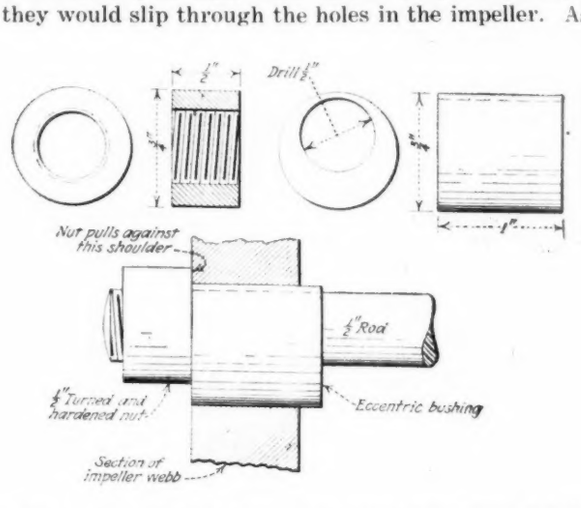
Where a change is made from alloy to copper end rings, it may be found that to get the same resistance in the copper rings as in the alloy ones, the cross-section of the new rings may have to be made so small that they will not have sufficient heat radiating surface, in which case they will overheat. In such cases copper rings cannot be used. P. W. SAWYER.

Cleveland, Ohio.

Special Drawing-off Bolts for Pump Impellers

In overhauling a three-stage centrifugal pump, the impellers had to be removed in order to replace worn wearing rings and bushings in the diaphragms between the impellers. As the impellers were all tight on the shaft and the diaphragms separating the impellers made it impossible to get a nut on the end of a pulling-off rod when pushed through the ¾-in. holes provided in the web of the impeller, a special drawing-off rig had to be made.

Two eccentric bushings of ¾-in. cold-drawn steel, and two standard ½-in. nuts were turned to ¾ in. diameter so they would slip through the holes in the impeller. As



Special nuts and bushings used with drawing-off bolts

this gave a shoulder of only ⅛ in. when the bolts were in place, we hardened the nuts to prevent their shearing off and pulling through the hole.

To put the bolts in place, the nuts were screwed on and pushed through the holes, then the eccentric bushings were slipped over the rods and pushed into the holes in the impeller. This prevented the rods from pulling through by making the nut shoulder against the impeller as shown in the illustration. This worked satisfactorily and the impellers were removed without difficulty. The same idea might be used in other places difficult to get at. J. O. REICHEN.

Bisbee, Ariz.

Comments from Readers

Air or Vacuum Chamber on Pump Suction

I have been reading the articles that have appeared in *Power* as to whether the chamber on the suction line of the pump is properly called an air or a vacuum chamber. My conclusion is that it may be termed either a vacuum or an air chamber, depending on pumping conditions. If the water is below the pump and is delivered to it by atmospheric pressure, it would be a vacuum chamber; otherwise, if the water is above the pump and is delivered to the pump by gravity, that would cause it to become an air chamber.

This can be easily proved by opening the petcock at the top of the chamber. If the water is below the pump, the air will rush in through the petcock; if the water is above the pump, the air will be found to rush out.

Chicago Heights, Ill. R. O. MORRISON.

Outwitting the Smoke Inspector

With reference to the comment by Richard Parrott in the April 12 issue on the article by A. A. Fette on "Outwitting the Smoke Inspector," Mr. Parrott says that the sulphur content in coal burns to SO_2 gas and this, when combined with the moisture from the steam jets installed to reduce the smoke condition, causes corrosion.

I agree with Mr. Parrott on this statement, but there has always been a question in my mind whether the burning of wet coal in a boiler furnace would not also produce a corrosive effect.

Engineering authorities disagree as to whether it is good practice to fire coal wet or dry, some claiming advantages for one method, while others assert the reverse.

I would like to have the opinion of other engineers on this subject. E. R. WEBBER.

Fairmont, Minn.

What About the Water Level?

The article on page 631 of the April 26 issue entitled "What About the Water Level?" prompts me to submit the following:

Charles Lamb once wrote a story about a Chinese farmer who was accustomed to allow his pig the privilege of sharing his humble hut. The farmer was unfortunate enough to have his house get on fire and the pig was unlucky enough to be unable to escape the catastrophe. In attempting to salvage something from the ruins, the Chinaman came upon the neatly toasted carcass of the porker, which on sampling he found to be exceptionally good. So delighted was he with the new delicacy of roast pig that he duplicated the conditions and burned down another house in order to obtain more roast pig.

The readers of *Power* are not interested in roast pigs, but the story illustrates how easy it is to observe an effect and then inaccurately assign it to certain causes which may be only incidental factors. Mr. Parker, in the article referred to, traces priming in water-tube boilers to a deficiency in steam liberating surface and in turn assigns the reduction in priming to increased liberating surface.

Steam liberating surface is a term which, in spite of many years of usage, really means little, and the little it does mean is not what the average engineer thinks it is. The sketch, Fig. 1, illustrates a longitudinal header-type boiler. The bulk of the steam is generated in the tubes and issues from the up-comer nipples at *A*. The steam bubbles are much lighter than the water, and they break from the surface immediately above the up-comer nipples unless restrained by throt-

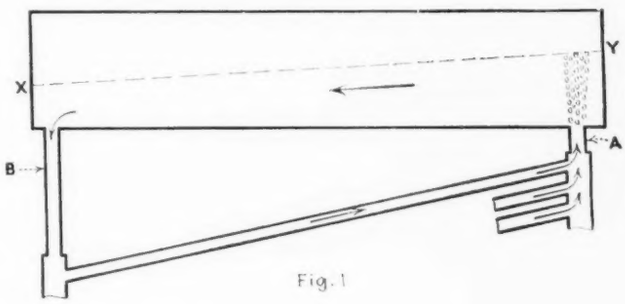


Fig. 1

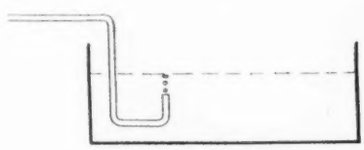


Fig. 2

Fig. 1—In a longitudinal header-type boiler the steam liberating surface is the total area of the up-comer nipples. Fig. 2—Bubbles rise immediately over tube and not from entire surface

tling devices or baffles. The true steam liberating surface is the total area of the nipples, and once the boiler is built it is beyond the power of the operator to change it.

The usual conception of steam liberating surface is that marked *XY*, and there is an erroneous idea that the steam issues uniformly from this surface. This might be approximately true if the heat were all applied to the drum shell, but we know that this is only a small part of the heating surface. The reader can satisfy himself by placing a pipe in a pan of water as shown in Fig. 2 and blowing in the pipe. The air bubbles will rise immediately over the tube, and no matter how hard one blows, it will be impossible to make them break from the entire surface of the water. The same thing is true of steam bubbles.

There is considerable turmoil over the nipple *A* where the steam is liberated and an appreciable amount of water in various-sized particles is thrown into the steam space. When Mr. Parker and his efficiency man lowered the surface *XY* they moved the source of this turmoil farther from the point of steam outlet and cut down the chance of slugs of water being sent into the

steam line, although the steam liberating area was just the same as before.

Mr. Parker is quite right in pointing out the error introduced by the greater specific gravity of cooler water in the water-column connections, and with certain types of boilers this error can be serious. Mr. Parker also pointed out an important point when he remarked that the level shown in the glass is never the true level except when the boiler is cold. The water flowing out of the up-comer nipples at *A* must flow back to the down-comer at *B* and for water to flow a difference of level is required. This inaccuracy of the water column under load is true for all boilers where the water glass is connected to the main path of circulation.

The area of the surface *XY* does have an important meaning in connection with the rapidity with which the water level will drop under inadequate feeding, but that is another story, not connected with the Chinaman's conclusions on the proper method of securing roast pig.

ELMER S. SMAIL.

Oak Park, Ill.

Dollar Efficiency Versus Technical Excellence

There are times, I fear, when the college-trained technician fails to realize the importance of the commercial features of his job. The kind of education that the average engineer receives is quite likely to place great emphasis on the purely technical phases of his future calling. The importance of formula has been drilled into him to such an extent that often he gets the notion that if he only knows the rules, he can solve any problem with the mathematics. A lot of theory and some practice have been crowded into his four years' course, but the most important subject, "economics," has usually been slighted; at least, it was in my case. It is seldom that he completes his course skilled in the use of that all-important tool, "money"; that is, how to spend the other fellow's money economically.

How often we hear it said of so and so that he is a crackajack engineer, but that it takes a gold mine to finance his projects; that he can put up structures that cannot be beaten when judged by purely technical standards; that in his line he is as much the artist as the painter is in his. In short he can produce a finished job if the cost is left out of the calculation, which is only another way of saying that he can correctly design and construct a project, which may be a money maker thereafter or the graveyard of the investor's money. Because these statements are so often true, the engineer has earned the reputation of being a poor business man.

Some years ago I was employed by a firm of consulting engineers as a draftsman. They were specialists in hydro-electric developments. One of their jobs had to do with a water-power project in the South. To expedite the work, a constructing company was formed and I, among others, was sent with this outfit to work in the office in the field. It had been decided to do practically all the designing and drafting where the structures were to be built. The smallness of the undertaking made this feasible. As the office force was small, I was called upon to try my hand at everything from blueprint maker to structural designer. Fortunately, I had operated a water-power plant in the West and had done some designing in the office of a public utility. Anyway, whether I was competent to do so or not, I made most of the preliminary drawings.

The governing factors controlling this undertaking were all economic; technically, the job was an easy one. It was simply a case of damming a small stream and building a power house a short distance below the dam. The dam was only 35 ft. high; that is, it created a head of 35 ft. on the turbines. Two 2,500-kva. turbine-generators were to be installed. At the time this project was started, the territory was being supplied with electricity by a combination ice and electric-light plant. This plant would manufacture ice during off-peak hours and supply current from twilight to midnight. It was in a dilapidated condition, and the kind of service it rendered was as poor as the equipment. The territory was growing slowly; the prospects for immediate paying business were slight. House wiring was in its infancy, and power business was in the dim and distant future. Electricity was held in more or less suspicion by these mountain people. Such being the case, common sense dictated that whatever was put up, it must not cost much. My employer did just this thing, for when the final plans came through they showed a design that was as simple as it was possible to make it. Every piece of equipment that was used was indispensable.

Now as to how I handled the situation, that which follows will explain in detail.

I had been taught the value of a good job. "What is worth doing at all is worth doing well" was one of the proverbs that had been preached to me. The possibility that "goodenough is best," was a saying, the truth of which I was to have impressed upon me later in life. In going at this proposition, I designed as if cost was of no importance at all. My aim was to design a first-class engineering structure that would be a credit to the profession. The matter of cost was for someone else to worry about. I was not concerned about its earning capacity; fixed charges meant nothing to me.

My designing was done in a small office overlooking the job site, but before any work could be started, each drawing had to be approved by an engineer representing the bond house putting up the money. In the case of preliminary plans they all had to be sent to the home office to get the general approval of the consulting engineers representing the moneyed interests.

Finally, the preliminary drawings were finished and dispatched to headquarters. My expectations were high when the drawings left on their trip to the north country. I firmly believed that they would all come back with the official O.K. You can then imagine my surprise and dejection when the plans were returned, not only not approved, but accompanied with a letter explaining what was wrong with them. The letter stated that although the plan I had worked out would, no doubt, do the work, it was too costly. Among other things the letter went on to say that good engineering was inseparably tied to good business. That if the project was not a good business risk, it was poor engineering to go on with it. But the final remark was the one I have never forgotten. Here it is: "Always remember that a good engineer is the fellow who can do with one dollar what anybody can do with two."

It was a valuable lesson for me and doubly profitable because it came when I was young. My error in judgment, due to lack of experience and proper training, had

been caught before any irreparable damage had been done. Not many of life's lessons are purchased so cheaply.

Now for an incident that did not end so happily. The same thought is back of this story as was the basis of my own personal experience. This also is a case of an engineer who builded too well but not wisely.

This narrative also has to do with a water-power project. The stream to be dammed was in a Northern State. The development would be located about fifty miles from a city of over one million population. Markets were already available for all the power that could be developed at the site. The station was to operate in parallel with three others, two steam and one water. The new plant was laid out for four units, each of 1,250 kva. The hydraulic head was to be 150 ft. The actual construction work was to be done by a subsidiary company organized for this special purpose by the directors of the operating company. The funds to carry on the work were to be provided by a city banker.

Actual construction was begun soon after the winter breakup. Work on the dam and power house was started at about the same time. The total yardage of concrete in the dam was not great and it should have gone in expeditiously but didn't. For some reason the transportation end of the job did not function properly. Materials did not arrive on time. Broken-down trucks seemed to block the roads whenever the call for materials was most urgent. The road tangle would finally get straightened out, and then something would jam on the job itself. Finally, word came from the man putting up the money that a halt must be called, because all the money that the job was estimated to cost, had been used. This was surely a fine state of affairs! What could be done? If the job was stopped, all was lost; if it went on, it might result in more good money following that which was sunk in the partly finished project. After due deliberation it was decided to try to rescue the investment by adding more to it.

To make a long story short, before the development was completed the cost had become nearly double the original figures. Here again was a case of a first-class engineering job that was doomed to failure from the start because it could not show a profit on so large an investment.

What was the result? Just this: The engineer, who was also vice-president and general manager of the operating company, lost his job and any interest he may have had in the property. The banker sold out. There was a reorganization, and when the smoke cleared away our technical man was out of it, shorn of his title and salary; a martyr to the cause of a good job that didn't pay.

These stories have been cited as reasons why we technical men shine with such a dim light into the notice of the hard-headed business man or banker. Now pause while we hear the protests from the ranks of the engineers. In too many instances, the man with the money has found, to his sorrow, that many of us technical fellows figure too optimistically the amount of money it will take to do a job. It sometimes looks as if we closed our eyes to the facts, for fear that our projects would never be started if the fellow who foots the bills knew what was ahead of him. For isn't it the rule, rather the exception, that the cost of most structures exceeds the estimate?

The engineer is blamed for this condition, and if he is not the guilty party, who is? If, after his calculations have been made and his estimates checked, the costs he has figured provide only funds enough to do part of the job, then why shouldn't he shoulder the responsibility, when those who hold the purse strings demand an accounting? To paraphrase Mark Antony, "I pause for a reply." C. W. REYNOLDS.

Binghamton, N. Y.

What Is the Best Type of Furnace for Return-Tubular Boiler?

In reply to the request of Burton M. Wheeler in the April 26 issue for information concerning hand-fired boilers, I am writing my experience in this line. As he intends to force the boiler, the height of the furnace above the grate should be not less than 4½ ft., and 5½ ft. would be still better. This exceeds any hand-fired installation as originally made, but boilers have been raised to this height with beneficial results. The usual furnace height of 30 to 36 in. is much too low for maximum rating. I have secured an increase in capacity of 25 per cent, and 10 per cent higher evaporation per pound of coal by doubling the original furnace height. The bridge-wall should be as low as possible—not over 24 in. Nothing is gained by a high bridge-wall, and at high ratings the low wall will reduce the chances of leaky girth seams.

I have in mind an installation of hand-fired boilers set 4 ft. 6 in. above the grates, that evaporate 10.2 lb. of water per pound of coal of 14,200 B.t.u. heating value, the average boiler and furnace efficiency being 75 per cent. A rating of 140 per cent is carried easily with the hand damper throttled to give 0.28 in. draft over the fire.

Lest some readers should consider 5½ ft. an excessive furnace height, I will quote the minimum furnace height demanded by a large manufacturer of underfeed stokers. For a 72-in. boiler the height required is 8 ft. As to a furnace lining for side walls and door arches, there are several monolithic linings now available that should stand up satisfactorily for any rating that Mr. Wheeler is likely to develop with a hand-fired furnace.

Springfield, Mass. A. F. SHEEHAN.

How About Joule?

I have been a subscriber to *Power* since the first of this year, and the bit of philosophy at the head of the magazine section has always been my first stopping place in a preliminary survey of the whole book.

The issue of April 19 is now before me, open at the page entitled "The Unit of Heat," in which the possibility of tagging the unit of heat with a more appropriate name is discussed.

We are well acquainted with the names of units of measurement of many things used in connection with the engineering profession. Some of the units, or more directly stating it, the names of some of the units used, might give a clue to a name for the unit of heat.

Take for instance the volt, the ohm and the ampere. To these units have been assigned the names of men who were pioneers in the electrical field, and their names have thus been immortalized. Would it not be appropriate to treat the name of some outstanding engineer or scientist in this way? It is possible that this idea has been presented before; if so, please accept this as a second to the motion. JAMES GRANT.

Calgary, Alberta.

New and Improved Equipment

Johns-Manville Radiator Control Valve

With a view to providing a simple radiator valve that will not only give control or regulation of radiator temperatures, but will cause circulation of the heating medium and uniform distribution of temperature over the entire surface of the radiator or heating coils, the Johns Manville Corp., New York City, has developed the valve shown in Fig. 1.

The valve is of the angle pattern and is built of brass and bronze with rough nickel-plated body and polished nickel-plated trimmings. It is designed for quick opening and closing, varying from tight closed to full open in a seven-eighths turn of the control handle *J*.

Referring to Fig. 1, which shows a

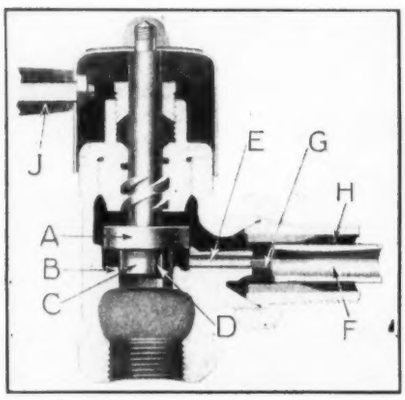


Fig. 1—Cross-section of radiator valve

cross-section of the valve, *A* is the disk, *B* the seat, *C* a sleeve attached to the stem below the seat and fitted with the slot *D*, *E* a nozzle and *F* a Venturi tube for creating a vacuum at the point *G* at low flow of steam.

In operation, when the spindle is raised, the slot *D* is gradually exposed, allowing an increasing amount of steam to flow through it until it has reached a certain point, after which the entire seat is exposed, allowing a full opening of the valve and the maximum amount of steam to flow through it. Before the slot *D* is fully exposed, the steam passes through it into the nozzle *E* and through the Venturi tube *F*. This creates a vacuum at the point *G*, which in turn causes a flow of the heating steam and air from the radiator back through the chamber *H*, where, mixing with the incoming steam, they are carried into the radiator again as indicated by the arrows in Fig. 2. As the mixture of steam and air in the radiator has a temperature lower than the steam supplied and this temperature is dependent upon the quantity of steam admitted through the nozzle *E*, it will be apparent that the uniform heating of the radiator at lower temperatures is readily accomplished.

When the valve is wide open, the disk is raised clear of the cylinder in the valve body and steam is admitted

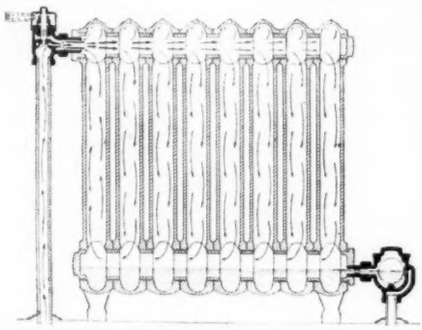


Fig. 2—Section of radiator with arrows indicating circulation

to the radiator through the port over the nozzle *E*, as well as through it.

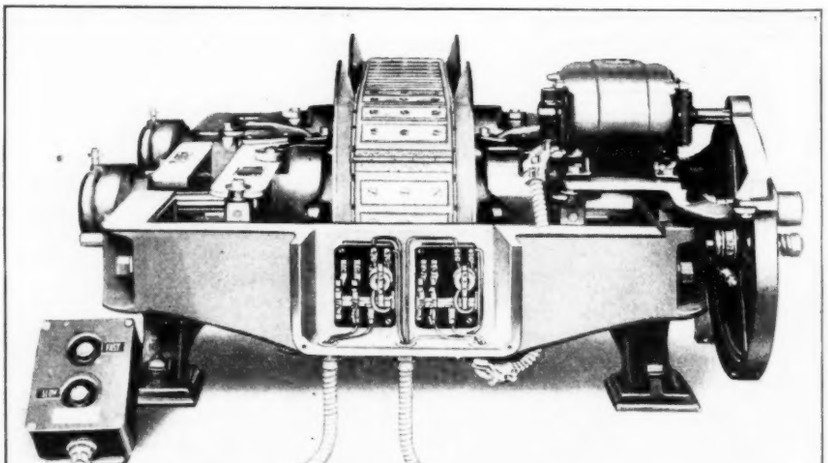
Fig. 2 shows the valve connected to the top of the standard hot-water type radiator now largely used in steam-heating systems. Where steam pattern radiators are used, the valve is connected with the bottom of the radiator.

Remote Control for Reeves Variable Speed Transmission

To the Reeves variable speed transmission a desirable accessory has been added in the form of a new electrical remote control of the push-button type, which permits regulation of the speed from any one or a number of positions remote from the transmission itself. The new device is incorporated in installations where it is necessary for the operator to interrupt his work to make the desired adjustment by hand and, owing to the inconvenience, perhaps not making all the speed changes desired and thus not using the transmission to its greatest efficiency; for example, in the case of the power-plant field, material-handling conveyors, stoker installations, and other equipment where the operator is at considerable distance from the transmission itself.

Various push-button electrical remote controls have been installed on the transmission in the past, but these have been more or less makeshift devices, and the new control under discussion constitutes the first of its type that is entirely self-contained on the transmission. As shown in the illustration, the control consists of a fractional horsepower reversible motor, mounted on a bracket above the shifting screw of the transmission and connected to the shifting screw by a single reduction of spur gears. The motor is started in either direction by one or more push-button stations operating through a magnetic switch. The latter is placed in a receptacle attached to the frame end of the transmission.

The motor is of the universal type so that either alternating or direct current may be used, and as the motor is of fractional horsepower, it is generally possible to use the regular lighting circuit. For protection in case the operator should hold the push-button beyond its slow or fast limits of speed, a safety clutch prevents jamming of the motor or transmission. It it is desirable for the operator to know the exact speed at which the machine is running, a tachometer may be located at the push-button station.



Reeves variable-speed transmission equipped with electrical remote control

Cochrane Unit-Control Valve for Pressure Filters

To facilitate the operation of its pressure filters by combining the necessary valves required for the various operations into one unit, the Cochrane Corp., Philadelphia, Pa., has developed the single-control valve illustrated. The valve, which is of the multiple-ported plug type, is designed to take the place of the five gate valves ordinarily required for the operation of pressure filters. It has five ports or connections and four positions, namely, for filtering, backwashing, filtering to waste, and closed, these positions being indexed on a dial mounted on the front of the valve, thus insuring correct manipulation.

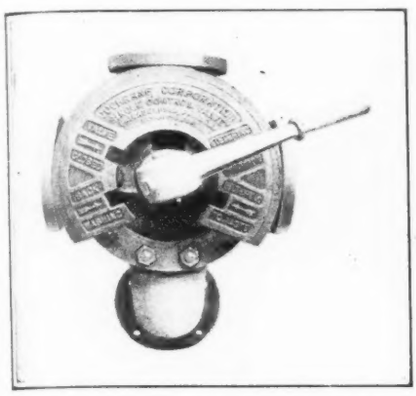


Fig. 1—View of valve, showing four positions

A view of the valve with the indicating dial attached is shown in Fig. 1 and the details of construction in Fig. 2. The plug of the valve is held to its seat by a seating spring and the pressure of the water on the unbalanced area. To prevent the plug becoming seized in its seat because of expansion or contraction, a means is provided for lifting it from its seat before turning it. This is accomplished by means of a cam on the end of the handle lever attached to the valve spindle, which engages with the valve housing when the end of the lever is drawn outward sufficiently to disengage the stop from the notch in the dial.

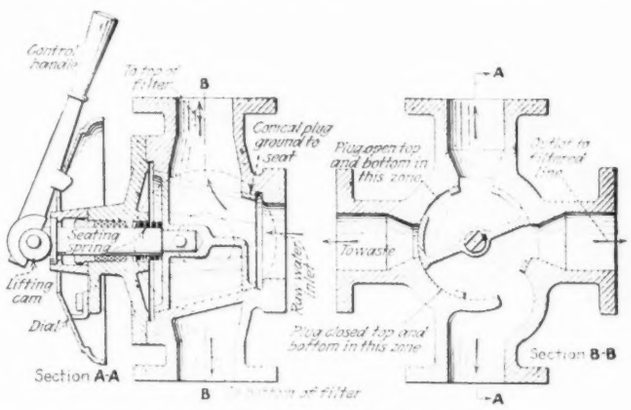
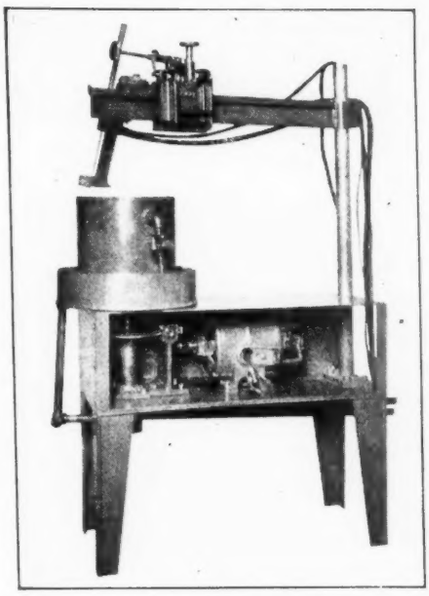


Fig. 2—Cross-section of valve



Arc-welding machine equipped with cooling device

Lincoln Machine-Driven Carbon-Arc Welder

The accompanying illustration shows a carbon-arc welding machine built by the Lincoln Electric Co., Cleveland, Ohio, in which provision is made for cooling the parts being welded.

The machine is designed for welding circular seams up to 12 in. in diameter and is fitted with cooling tubs around the revolving table which carries the piece being welded. The piece on which the welding is being done, may be partly or totally immersed in water during the welding operation. Cooling water is kept in circulation in the tubs while the welding is being done.

The novel cooling arrangement was developed to meet the requirements when welding high-grade alloy steels on which the heat disturbance due to application of welding heat must be reduced to a minimum. In the case of 12 per cent manganese steel the welding may be done with the piece totally immersed in water and the arc submerged. This cooling arrangement is said to be well adapted to the welding of manganese steel since the rapid quenching of the molten metal gives it the physical properties desired.

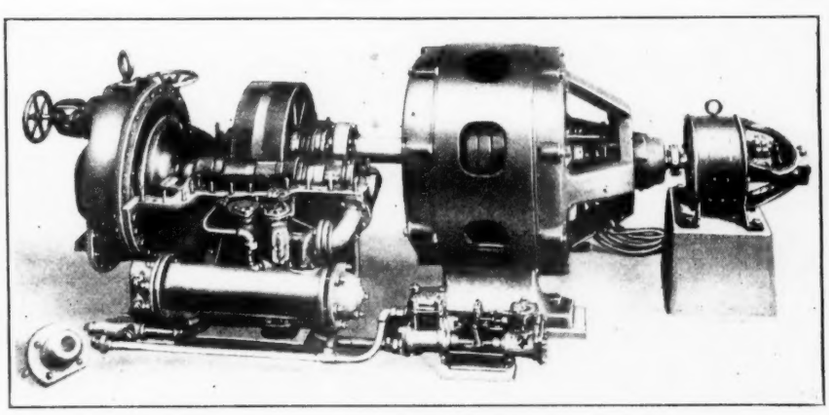
Westinghouse Geared-Turbine Unit

The illustration shows a type of geared-turbine unit now being put out in sizes from 75 to 500 kw. by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Although designed primarily for driving alternating- and direct-current generators, the unit is adaptable to other drives within the range of the gears.

The turbine has a single impulse wheel of the re-entry type running at 7,200 r.p.m. and connected with the generator through a double herringbone gear which is inclosed within the same casing. The impulse wheel is mounted on the end of the pinion shaft and this obviates the use of an outboard bearing, one gland and a coupling between the turbine and the gear.

The unit is equipped with an oil-pressure governor similar to that used on larger units manufactured by this company. The use of this governor allows the speed of the turbine to be varied through a wide range while the machine is in operation. A twin oil strainer, cooler and independent steam-driven oil pump are auxiliary equipment.

In addition to the standard overspeed safety governor the turbine is equipped with a restraining ring to prevent the bursting of the cylinder in the case of accidental extreme overspeeding. The steam chest is mounted directly on the foundation to obviate piping strains.



Geared-turbine unit with single re-entry-type impulse wheel

The Burning of Midwest Coals*

By E. L. McDONALD†

COMPARATIVE analyses of steaming coals from six different states and of results obtained when burning them on a forced-draft chain grate, with comments on the peculiarities in burning, troubles from slagging and excessive moisture and ash, and the gain from the use of preheated air.

STEAMING coals from Iowa, Missouri, Kansas, Arkansas, Oklahoma and Illinois are to be considered, as these are the steam coals available from the Midwest States. In Fig. 1 the shaded portions of the map show the coal areas under consideration and the black portions, the more active mining districts.

In Illinois the greater portion of the steam coal comes from the Peoria-Springfield district. The quality of this coal, which is all of bituminous rank, is poorest in the northern part of the state and increases in value toward the south, with the exception of an area north of East St. Louis. The southern part of the state supplies most of the domestic coal, the screenings and slack from which are, of course, available for steaming purposes.

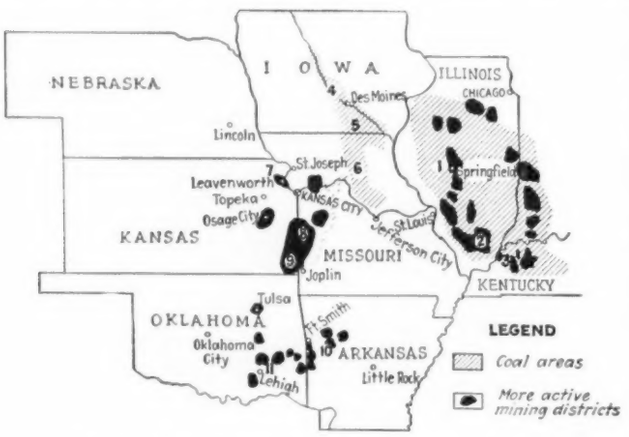


Fig. 1—Map of coal areas in Midwestern States

From the Brevier seam, running down through Iowa along the Des Moines River Valley, come the bituminous coals suitable for steam purposes, but the quality and quantity available vary excessively throughout the state. As a whole the coal is poorer than Springfield District Illinois or Missouri coal, although some that is fairly good is available from scattered spots.

The north Missouri fields are a continuation of the Brevier seam running down from Iowa. While the coal as a whole is of better quality than Iowa coal, it will not average as good as Springfield District Illinois coal. In the southwestern part of Missouri the Lower Weir Pittsburg seam produces bituminous coal of a quality equal to Springfield District Illinois coals and is mined more extensively than the Brevier seam.

There are three distinct mining areas in Kansas, all producing bituminous coals: One in the vicinity of Atchison and Leavenworth, from which a poor grade about equal to Iowa coal is obtained; the second, a small district confined to Osage County, producing a fairly good grade but in small quantities; and the third and most important area, known generally as the Cherokee-Pittsburg district, in the southeastern part of the state. As a whole this coal is equal in heat value to that of southern Illinois.

Oklahoma has several mining districts scattered over the central and eastern parts of the state, from Tulsa down to Lehigh and east from these points. These districts produce coal of both bituminous and semi-anthracite rank, some being high in coking qualities.

There are six mining districts in Arkansas producing semi-anthracite and what is known locally as Arkansas anthracite, which approaches in analysis Eastern semi-anthracite, but is fragile in structure, so that it easily breaks down to slack.

Summing up, there are available from the Midwest fields, coals ranging from strip-pit bituminous to deep-shaft Arkansas anthracite. The accompanying table, giving analyses of these coals, indicates the great variation in rank and quality. The analyses shown are not extreme in either direction, but have been picked out to represent average good and average poor coals from these fields. The analyses were made on the coals as received at the power plant. As shown in the table, heat values vary from 7,400 to 12,850 B.t.u., ash from 6.78 to 31.96 per cent and moisture from 3.5 to 20.8 per cent.

While the burning of coal in pulverized form is undoubtedly the ideal method from the viewpoint of thermal efficiency, there is more reliable information available on the burning of these coals on forced-draft chain grates, so that the comments following will be confined to results obtained on a forced-draft chain grate unit installed in the Northeast Station of the Kansas City Power & Light Co. This type of stoker is well adapted to the burning of Midwest coals, its merits lying chiefly in the ability to control the air supplied to any portion of the fuel bed. The extent to which this control of air is desirable when burning different grades of Midwest coal is shown in Fig. 2.

It is interesting to compare the different zone pressures when burning a Kansas and a Missouri coal, both developing the same boiler rating, and again, the contrast between Illinois and the Arkansas coals when developing the same boiler output. The need for these different air pressures is caused principally by rapidity of ignition, coal sizing, percentage of ash in the coal and its fusion temperature. Coals slow to ignite demand less air in the front stoker zones. Theoretically, the temperature required for the ignition of the fixed carbon in bituminous coal is about 770 deg. F. Ordinarily, 1,800 to 2,200 deg. F. actually exists at the front of the arch.

Coals fine in size require thinner fuel beds and usually more pressure to break through the fuel bed. Arkansas anthracite is in this class. Being fragile, it slacks easily and 1¼-in. screenings will contain fines of which 75 per cent will pass through a ¼-in. screen, whereas 1¼-in. Illinois screenings will contain only 30 per cent fines passing through a ¼-in. screen. Ash fusion temperatures of some of the lower grades of Midwest coals will run as low as 1,800 deg. F. and in others range between 2,000 and 2,180 deg. F.

With molten ash tending to mat over the grate, more air pressure naturally is required to overcome the resistance.

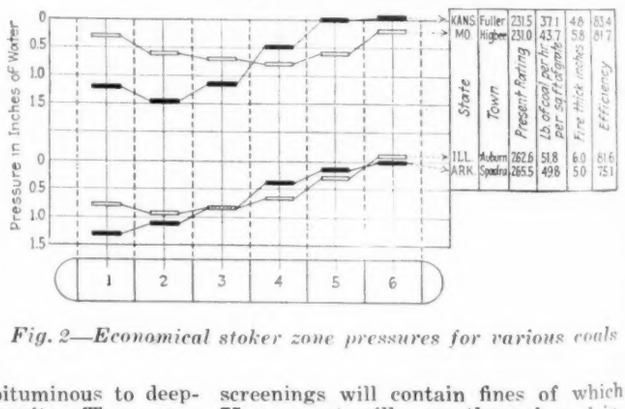


Fig. 2—Economical stoker zone pressures for various coals

*Abstract of paper presented before the A.S.M.E. regional meeting at Kansas City, April 4-6, 1927.

†Efficiency engineer, Kansas City Power & Light Co.

Ash fusion at a low temperature and during the early stages of combustion will embed carbon particles, thereby preventing air from coming in contact with them to complete the combustion. While this occurs to some extent in the burning of any kind of coal, it is more pronounced in most of the Midwest coals with their high percentages of low fusing ash. High ashpit losses from this cause, together with the high moisture and hydrogen content, resulting in unavoidable stack losses, are three reasons why efficiencies with Midwest coals are not so good as those obtained with some Eastern coals.

Moisture plays an important part in the burning of Midwest coals on chain grates. For example, the average moisture content of Missouri coal is 12 to 14 per cent, but, as received, this coal often contains over 20 per cent moisture. Under such conditions ignition and proper combustion are difficult. On the other hand, coal is received from other fields, particularly Arkansas, with a moisture content too low for good firing conditions. Moisture must be added to the coal before firing, so as to obtain a uniform fuel bed, to prevent holes from forming and carrying the finer particles up through the boiler and out the stack.

Each of these Midwest coals has its own peculiarities in burning. Most Missouri coals burn with a long, heavy flame and at normal rating develop a furnace temperature of about 2,700 deg. F. Kansas coals burn with a somewhat shorter and clearer flame and normally develop a furnace temperature of about 2,850 deg. F. Many of the Kansas coals are of a coking nature. Oklahoma coals can develop high furnace temperatures, and most of them are highly coking coals.

Arkansas anthracite burns with such a short, transparent flame that practically the entire fuel bed is visible. Owing to its fineness and light structure millions of small incandescent carbon and ash particles are lifted from the fuel bed, some falling back on the rear of the stoker like snow and a great part traveling through the boiler passes in the form of red-hot sparks. This coal cannot be burned successfully on a natural-draft chain grate.

The high ash, sulphur and iron content of most of the Midwest coals makes slagging problems acute, so that facilities for removing the heavy slag deposits from the first pass of the boiler must be provided, in the form of soot blowers and rodding doors in the setting. Even with these provisions boilers must come down every 25 to 30 days for a general cleaning.

Bituminous coal commonly is referred to as a "free-burning coal." As a whole, this is correct, but with some of the Midwest coals running up to 35 per cent ash and impurities, the expression "free burning" is a misnomer, for on certain equipment it is often difficult to maintain ignition.

Ignition of these low-grade coals has been stimulated in the last few years by the application of preheated air for combustion. An air temperature of 200 deg. F. is not detrimental to the stoker or furnace lining, whereas in recent installations trouble has been experienced from heating the air to 500 deg. F. More rapid combustion, less excess air and higher efficiencies are the advantages to be credited to preheated air. The effect of its use with a certain Midwest coal is shown in Fig. 3. The top curve in the chart indicates the percentage gain due to the heat units absorbed from the flue gases. From the difference in efficiencies, shown in the lower curve, it is evident that the gain by preheating the air, particularly at higher ratings, is in excess of that accounted for by the heat absorption from the flue gases.

Efficiencies and capacities obtained with average Midwest coals are shown in Fig. 4, in which the curves give actual results obtained on tests of five representative coals from five of the states. These results were obtained from a modern cross-drum boiler unit of large size, equipped with a forced-draft chain grate, economizer and air preheater. Unit efficiencies, except when burning Missouri coal, range from 81 to 84 per cent at 270 per cent of rating. Because of excessive slagging and fluxing of the ash and firebrick at high rating, the units normally are operated at about 240 per cent of boiler rating.

Summing up the burning of Midwest coal, it may be said that while each coal has its own peculiarities and must be burned accordingly to obtain efficient results, all these coals can be burned with good success if properly handled on the proper equipment.

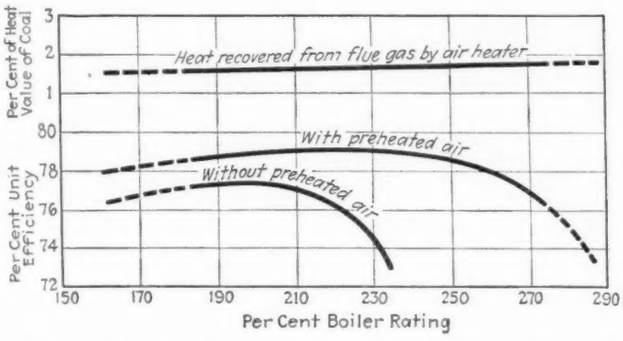

Per Cent of Heat Value of Coal
Heat recovered from flue gas by air heater
With preheated air
Without preheated air
Per Cent Unit Efficiency
Per Cent Boiler Rating

Fig. 3—Relative efficiencies when burning Hume Missouri coal with and without preheated air

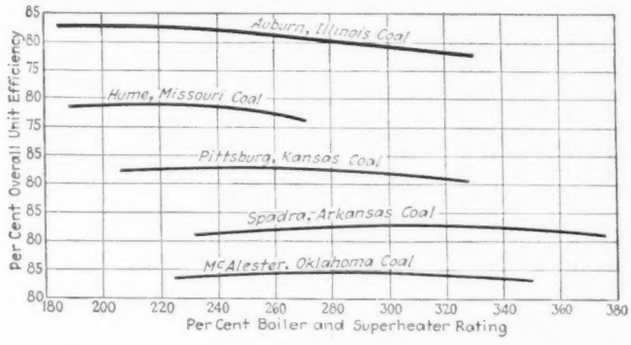


Fig. 4—Comparative efficiencies with five different Midwest coals

ANALYSES OF TYPICAL MIDWEST COALS AS RECEIVED

State	County	No.	Grade	Moisture	Ash	Vol.	F.C.	B.t.u.	B.t.u. Dry
Illinois	Sangamon & Nacoupin	1	Good	14.20	11.89	35.16	38.75	10,350	12,070
			Poor	13.34	13.80	31.00	41.86	9,915	11,440
Illinois	Franklin	2	Good	13.93	9.27	34.80	42.00	11,190	13,001
			Poor	12.94	11.62	33.00	42.44	10,827	12,425
Iowa	Boon	4	Good	12.30	18.60	37.20	31.90	9,773	11,144
			Poor	13.20	27.20	28.50	31.10	7,503	8,640
Iowa	Appanoose	5	Good	20.80	24.12	28.00	27.08	8,741	11,020
			Poor	17.33	31.96	25.00	25.71	7,408	8,596
Missouri	Randolph	6	Good	13.25	19.09	30.33	37.37	9,492	10,941
			Poor	13.45	23.45	28.00	35.10	8,767	10,117
Missouri	Bates	8	Good	13.88	18.46	30.66	37.00	9,702	11,266
			Poor	13.55	23.08	28.62	34.80	8,680	10,030
Arkansas	Sebastian & Johnson	10	Good	3.50	11.57	14.93	70.00	12,850	13,316
			Poor	3.50	21.36	10.30	64.84	11,880	12,325
Kansas	Leavenworth	7	Good	10.69	24.38	27.60	37.33	9,465	10,620
			Poor	11.41	27.17	25.93	35.49	8,845	9,990
Kansas	Crawford & Cherokee	9	Good	6.80	13.86	27.57	51.87	12,187	13,050
			Poor	7.50	19.36	27.31	45.83	10,793	11,690
Oklahoma	Pittsburg	11	Good	6.76	6.78	15.25	71.17	12,817	13,377
			Poor	5.00	18.83	12.60	63.57	10,950	11,526

WITH ORDINARY GASES the throttling process does not produce any material change in temperature. In the rapidly moving jet, the temperature is reduced considerably, but when the velocity has been dissipated by friction, the temperature of most gases comes back very close to the original value. That is why the air refrigerating machine cannot use an expansion valve, but must introduce an air-engine cylinder to reduce the heat content of the air, and thereby to reduce its temperature. On the other hand, if liquid, such as liquid ammonia, under high pressure, and at a temperature near the boiling point for that pressure, is allowed to flow into a region of low pressure, a portion of it must evaporate to keep the aggregate heat content the same. Incidentally, this evaporation is only a small portion of the total — perhaps one-sixth of the whole. The remaining liquid is evaporated only upon receiving heat from outside. In a refrigerating system this is done in a brine cooler or other "expansion coil" in which the action is strictly analogous to that in a boiler.

Diesel Exhaust Temperatures*

By V. L. MALEEV†

THEORETICALLY, the power developed by an internal-combustion engine can be determined by taking indicator diagrams. However, in actual practice only really large engines will have an indicator drive rig. Although in the majority of cases there are indicator plugs in the cylinder or cylinder heads, there are no means of obtaining the indicator-drum motion, at least with any appreciable degree of accuracy.

Lately, it has been repeatedly stated in technical literature that the exhaust temperatures provide means for checking the working conditions of the engine. A rise above normal temperature, it is claimed, indicates that something is wrong with the engine.

It was decided to attack this question from a different angle, to find out how the exhaust temperature of an oil engine is influenced by the load conditions, assuming that the engine is properly adjusted. With this object in view several series of tests were performed with three oil engines, all of the same make.

The three main factors which are influencing the exhaust temperature of an oil engine are: Load, speed or revolutions per minute, and the heat absorbed by the cooling water. We did not investigate the influence of the cooling water, for generally the cooling conditions can be maintained as desired, independently of the engine load. Therefore, we had only two factors left to be investigated—load and speed.

We should have investigated the influence of the mean indicated pressure, but being primarily interested in the actual or brake load, we conducted the tests with certain brake loads and later from these we computed the influence of the mean indicated pressure.

The first series of tests were performed with a three-cylinder, solid-injection Western-Enterprise oil engine, which has a bore of 9 in., a stroke of 12½ in. and is rated 80 hp. at 330 r.p.m.

The tests were conducted in the following manner: First the engine was run with half-load on the brake and at low, about three-fourths of the normal speed; then maintaining the same brake scale reading, the speed was gradually increased by about 10 per cent of the normal speed at a time for another series of readings until the engine was running at full speed. Tests were made only after stationary thermal conditions were attained, as evidenced by the constant temperatures of the exhaust gases and of the discharge cooling water. Thus a series of tests at a certain speed consisted of four runs.

TABLE I.—EXHAUST TEMPERATURES

Test No.	Brake Load, Lb.	R.p.m.	Exhaust Temperature, Deg. F.	Fuel Consumed, Lb. per Hr.	Cooling Water: Gal. per Hr.	Cooling Water: Inlet, Deg. F.	Cooling Water: Outlet, Deg. F.
1	121.25	237	370	13.64	563	68	84.5
2	121.25	266	386	15.65	612	68	85.5
3	121.25	301	404	17.95	685	68	87
4	121.25	329	419	19.90	730	68	89
5	181.75	240	476	18.11	570	68	88
6	181.75	270	501	20.70	632	68	90
7	181.75	299	525	23.20	681	68	92
8	181.75	328	545	25.82	728	68	95
9	242.5	239	600	23.44	568	68	94
10	242.5	269	630	26.90	627	68	97
11	242.5	298	659	30.14	678	68	100
12	242.5	330	690	33.78	732	68	103
13	266.75	240	663	26.25	570	68	98.5
14	266.75	268	692	29.85	622	68	102
15	266.75	300	727	34.01	683	68	106
16	266.75	332	762	38.20	736	68	110

After this the engine was slowed down to the initial speed and the brake load increased up to three-fourths of the normal and again a series of four tests run with increasing speed. Then a series was run with full brake load and finally one with a 10 per cent overload. In addition to the r.p.m., the temperatures of the exhaust gases and the cooling water before and after the engine, we measured the amount of cooling water and the amount of fuel consumed. This enabled us to compute a complete heat balance for all 16 tests data of which are in Table II.

Painstaking care was taken to keep the engine during all tests in perfect working conditions. If there was any doubt about the spray holes in a fuel nozzle being plugged up, the engine was stopped, nozzle cleaned, and the test or tests repeated. Only tests with entirely reliable results are included in Table I.

Table II contains figures derived from the data of Table I and also from some preliminary information; namely, the mechanical efficiency was found from several preliminary tests to be practically independent from the speed, but dependent from the load.

In order to check the correctness of the exhaust temperatures measured during the tests by means of a thermocouple, a complete heat balance was computed for each test. The last column in Table II shows that the heat not accounted for, radiation losses and inaccuracy of the test performance, varies from about 5 to 10 per cent, which must be considered as indicating sufficient accuracy in view of the great number of unavoidable small errors of measurements.

With these computations completed, we turned to the main object of our tests—finding a relation between the engine load and the exhaust temperatures. First, we plotted the results of our test in a diagram with the exhaust temperatures for ordinates and r.p.m. for abscissas. Drawing lines through points corresponding to the same brake m.e.p. or corresponding to the same m.i.p., we found that these lines are practically straight lines.

It was then possible to build up a diagram giving the relation between the exhaust temperatures and indicated loads on the engine, at different constant speeds. The corresponding lines are curves slightly convex toward the axis of abscissas and show a very uniform curvature. These curves can be used for determining the horsepower developed by the engine.

However, for practical use it is more convenient to have a diagram with the exhaust temperatures as ordinates and mean effective pressures instead of mean indicated pressures as abscissas.

Such charts should be plotted for every engine, or at least every type of engine, while the engine is on the test stand of the factory. The chart should be part of the engine equipment, together with a reliable exhaust-temperature pyrometer, thus enabling the engineer later to determine the actual load of the engine with two readings, one of the exhaust temperature and one of the engine speed.

TABLE II.—CALCULATED RESULTS

Test No.	Load, Electrical Hp.	Mech. Effic. Per Cent	I. Hp.	Brake M.e.p., Lb. per Sq.In.	Indicated M.e.p., Lb. per Sq.In.	Heat Balance, in Per Cent of Full Load Heat: Exhaust Gases	Heat Balance, in Per Cent of Full Load Heat: Cooling Water	Heat Balance, in Per Cent of Full Load Heat: Radiation Etc.
1	28.75	65.8	43.9	40.25	61.3	19.6	29.5	8.3
2	32.25	65.8	49.2	40.25	61.3	19.8	29.7	8.9
3	36.5	65.8	>5.6	40.25	61.3	20.2	31.4	7.5
4	39.9	65.8	60.8	40.25	61.3	20.3	33.4	6.8
5	43.6	74.0	58.9	60.4	81.6	20.3	27.3	9.4
6	49.0	74.0	66.2	60.4	81.6	20.8	29.1	7.8
7	54.3	74.0	73.4	60.4	81.6	21.2	30.5	6.5
8	59.6	74.0	80.5	60.4	81.6	21.4	33.0	4.4
9	57.9	79.2	73.1	80.5	101.7	20.5	27.4	10.8
10	65.2	79.2	82.4	80.5	101.7	20.8	29.3	9.4
11	72.25	79.2	91.3	80.5	101.7	21.3	31.2	7.4
12	80.0	79.2	101.0	80.5	101.7	21.6	32.9	5.9
13	64.0	80.7	79.3	88.6	109.8	20.7	28.8	10.5
14	71.4	80.7	88.5	88.6	109.8	20.9	30.7	9.3
15	80.0	80.7	99.2	88.6	109.8	21.2	33.0	7.3
16	88.5	80.7	109.7	88.6	109.8	21.6	35.1	5.4

†Mechanical engineer Western Machinery Co., Los Angeles, Calif.

*Abstract of paper submitted to the Oil Engine Conference, Los Angeles, Calif.

News in the Field of Power

Boiler and Vessel Inspectors To Meet at Nashville

Six technical papers of interest will feature the fifth annual meeting of the National Board of Boiler and Pressure Vessel Inspectors which will meet at the Hotel Hermitage, Nashville, Tenn., June 14-16, inclusive.

The sessions will be opened by the address of the chairman, Joseph F. Scott, chairman of the Engineers' License and Steam Boiler Inspection Bureaus. General discussion on officers' reports and reports of committees will follow.

In the afternoon three papers will be presented. "The Behavior of Materials Used in Boiler Construction When Subjected to Service Conditions" will be read by S. B. Applebaum, assistant technical manager of the Permutit Co., New York City. C. R. Texter of the metallurgical department of the National Tube Co., Pittsburgh, Pa., will offer "Corrosion, Its Cause and Prevention," while Edward A. Geohegan will address the board on "Destructive Effects of Free Oxygen in Steam Due to Its Decomposition During Superheating." In the evening there will be an informal dinner for members, guests and visitors at the Hotel Hermitage.

FROM PAPERS TO BARBECUE

"Fusion Welding on Boilers and Pressure Vessels," by S. W. Miller, Union Carbide and Carbon Research Laboratories, Inc., Long Island City, N. Y.; "Application of Electric Arc Welding to Heavy Vessel Construction," by T. McLean Jasper, director of Research A. O. Smith Corp., Milwaukee, Wis., and "The Dependability of the Riveting Art" (illustrated by motion pictures), by F. A. Jansen, president of the Hanna Engineering Works, Chicago, Ill., will complete the technical program.

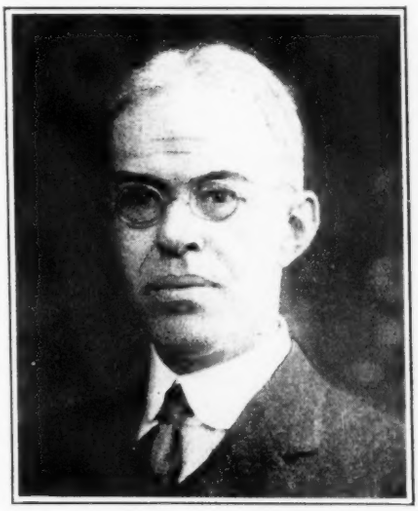
A sightseeing tour of the City of Nashville, ending at the Southern Country Club where an old time Southern barbecue will be served, is the entertainment feature of the afternoon.

Executive sessions and the election of officers will take place Thursday, June 16.

Miller Medal Established As Welding Award

At the annual dinner of the American Welding Society held in New York April 28, F. M. Farmer, president, announced the donation of an award, the gift of Samuel Wylie Miller, to be presented by the society annually in appreciation of work of outstanding merit in advancing the art and science of welding. The award is a gold medal, which will be known as the Miller medal in recognition of its founder.

S. W. Miller has been one of the outstanding figures in the advancement of welding ever since its commercial inception. He is a past-president of the American Welding Society and a prominent and active member of the Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers and other scientific and engineering organizations. He has been long noted for his energetic insistence upon high quality and dependable



Samuel W. Miller

workmanship and upon the development of welding by all processes along lines scientifically well founded. He is consulting engineer for the Union Carbide and Carbon Research Laboratories, Inc.

In establishing this award, the details for the administration of which are not yet decided upon, Mr. Miller's object is to promote an appreciation of better welding and to encourage the study of those fundamentals which will lead to raising the quality of work done by the average operator.

In accepting the administration of this award on behalf of the American Welding Society, Mr. Farmer outlined briefly the history and ideals of its donor and expressed himself as being particularly gratified that during his administration the Welding Society should be granted the privilege of managing such an important contribution to the improvement of the welding industry.

South African Power Grows

During 1925 there were 1,512,107,260 kw.-hr. generated in South Africa, of which 97,213,470 were direct current, 1,271,984 alternating current, and 142,909,209 steam and air units. The output for 1924 was 1,422,816,609 kw.-hr., and for 1923 it was 1,319,974,595.

A.I.E.E. Men of Northeastern District To Meet

At the fourth regional meeting of the Northeastern district of the American Institute of Electrical Engineers, which will be held with the student convention of that district at the Maplewood Hotel, Pittsfield, Mass., May 25 to 28, inclusive, a number of papers interesting to power engineers will be offered.

The technical session the morning of Thursday, May 26, will be featured by four contributions. "Tap Changing on Transformers," by W. S. Moody, chairman, will be followed by "Changing Taps on Transformers Under Load," L. H. Hill, Westinghouse Electric & Manufacturing Co.; "Characteristics of Interconnected Power Systems as Affected by Transformer Ratio Control," L. F. Blume, General Electric Co., and "Load-Ratio Control Equipment," by Arthur Palme, General Electric Co.

Among other important papers should be mentioned three which will be read the morning of Saturday, May 28. They are: "Development of Automatic Switching Equipments in the United States and Europe," by A. H. Degoede, General Electric Co.; "Economic Power Factor Correction," by H. S. Litchfield, and "The Instability in Transformer Banks," by K. E. Gould, Massachusetts Institute of Technology.

Many Industries To Exhibit at Indiana N.A.S.E. Show

Thirty-three manufacturers from various parts of the United States, including six local concerns, have taken space in the Power and Mechanical Exposition to be held at the Anderson, Ind., Y. M. C. A. gymnasium in connection with the twenty-third annual state convention of the Indiana branch of the National Association of Stationary Engineers which is to be held May 26, 27 and 28.

Plans for the exposition and state meeting have been announced by Frederick L. Ray, general chairman of the committee on arrangements. Others on the local committee in charge of the convention include H. V. Wallace, August Steigler, J. O. Benefiel, Paul Ashby, George Billman, secretary, and Ralph H. Zellar, treasurer of the local branch.

An instructive program of lectures is being prepared and automobile rides about the city will be provided for guests. The Ladies' Auxiliary of the Engineers' Association is arranging teas, automobile rides, theater parties and a bazaar for lady guests. State officers who will be here for the convention include President George Carter, chief engineer of Indianapolis Power & Light Co.; F. L. Clifford, secretary of Kokomo; Emil J. Heeger, treasurer of Evansville.

Steam Unit Attains Peak of 500,000 Pounds

The world's record of steam produced by a single boiler has recently been made through the remodeling of one of the large steam generating units at the Fordson plant, formerly known as the Rouge River plant, of the Ford Motor Company.

As a result of the rebuilding of Unit No. 2 the production was more than doubled, and its peak production of 500,000 lb. of steam per hour goes on record as the highest capacity that has ever been attained by a single unit. The work of re-designing and rebuilding was carried out by the Combustion Engineering Corp., American subsidiary of the International Combustion Corp. For almost a year the reconstructed unit has been operated at an average capacity of 380,000 lb. per hour, with frequent peak limits of one-half million. As a result of successful performance three similar units in the plant are at present being rebuilt.

Power, in the issue of July 13, 1926, on page 41, published a description and drawing of this unit. At this time the International Combustion Engineering Corp. has devoted a special bulletin to its reconstruction entitled "500,000 Pounds of Steam Per Hour From One Unit."

Sales of Engines and Waterwheels in 1925

The extent to which the United States depends upon mechanical power is illustrated by the table below. According to the preliminary census reports for 1925 there were 10,086,852 hp. of steam turbines, steam engines and internal combustion engines sold in 1925, excluding gasoline engines built in the same establishments as the automobiles into which the engines are placed.

If the automotive horsepower be subtracted from the total there are 3,350,694 hp. devoted to power purposes.

Comparison of this table with data given in the 1923 Census reports shows that the horsepower requirements of the country are increasing, but at a declining rate.

In 1923 there was a total of 9,584,641 hp. of engines sold, of which 4,001,794 hp. were prime movers. In other words, the demand has decreased approximately 20 per cent in two years.

If the comparison be extended, it will be found that in 1923 a total of 1,813,324 hp. of steam turbines were sold, while in 1925 there were 1,111,888 hp. Likewise, the reciprocating steam-engine horsepower dropped from 537,789 to 208,311. Diesel and semi-Diesels increased from 198,197 to 409,390 horsepower. Comparison of waterwheel sales cannot be made, as in the 1923 reports give no horsepower totals, although 475 wheels were used.

A Smokeless Glasgow Looms!

A SOOTLESS city wherein happy housewives will face the annual spring cleaning carnival with as little worry as the weekly dust-up; Clydeside without a dingy pall; Glasgow air that will rival the resorts of health-seekers—in short, a smokeless industrial paradise!

Such is the vision conjured up by the prospect of universal adoption of a fuel now being produced within a few miles of Glasgow by a Manchester mining engineer, Charles Turner, the fruits of whose inventive efforts were shown to a party of industrial, scientific, and press representatives, and an inspector of the Fuel Research Board of Glasgow, Scotland, March 30.

Chicago Gets Midwest Power Conference in 1928

Announcement is made of the third Midwest Power Conference to be held in Chicago Feb. 14-17, inclusive, 1928. Next year's effort will be broadened by the participation of the local sections of the American Society of Heating and Ventilating Engineers, American Society of Civil Engineers, and the American Society of Refrigerating Engineers, in addition to the six societies that participated in the conference last year.

An organization meeting has already taken place and the committee appointed is giving active consideration to the program which is being planned to cover the various power interests of the participating societies in such a way as to make the conference of national importance. As the work progresses, announcements will be made of developments.

N.A.S.E. Shaping Plans for National Convention

Plans for the national convention of the N.A.S.E. in Los Angeles, Aug. 22-27, are taking definite form.

It is believed that enough delegates will go from the East to insure special train service on the outward trip. Delegates will return by such routes as they may prefer individually. To date 70 per cent of the exhibit space has been sold.

Electric Light & Power Plants Rated at 23,267,510 Kw.

According to statistics recently compiled by the United States Geological Survey, there were in the United States at the end of 1926, 2,058 public utility companies generating all or a portion of their energy output, of which number 1,953 were electric light and power companies. The remaining 105 were chiefly electric railway companies, but the number includes also a small number of manufacturing plants selling energy to the public as well as certain operations of the Bureau of Reclamation.

The total number of public utility plants was 3,807, 3,655 of them being credited to the electric light and power industry. The corresponding figures for installed capacity are 25,256,556 kw. and 23,267,510 kw., and the total energy outputs for the year 1926 were 73,398,314,000 kw.-hr. and 69,200,630,000 kw.-hr. respectively.

Engines and Waterwheels Sold in 1925*

	Number, by Rated Horsepower Capacity												Total		Value
	Under 5	5 to 9	10 to 19	20 to 29	30 to 39	40 to 49	50 to 99	100 to 499	500 to 999	1,000 to 1,999	2,000 to 4,999	5,000 to 9,999	10,000 and Over	Number	Rated Horsepower Capacity	
Steam engines:																
Reciprocating (other than traction)																
Marine	4							6	10	2				22	12,138	214,024
Stationary and portable	117	360	385	234	145	44	701	241	74	12	2	1		2,316	196,173	4,781,368
Steam turbines	1,042	145	201	96	100	89	275	355	46	49	43	15	19	2,475	1,111,888	9,125,801
Traction			4	23	41	26	7							101	4,127	257,623
Diesel and Semi-Diesels																
Marine		53	172	82	111	116	257	296	10	2	6			1,105	103,827	6,760,933
Other	5	63	257	635	132	184	789	873	43	15				2,996	305,563	15,218,684
Other internal-combustion engines (not including tractors)																
Marine:																
Stationary	1,752	2,211	3,678	1,174	1,419	765	806	1,047	34		5			12,891	483,476	8,993,962
Detachable	24,628													24,628	64,008	2,203,932
Motor-vehicle and aviation		803	122,582	147,610	21,840	6,132	4,593	447	84					304,091	6,736,158	55,612,881
Other stationary and portable	157,149	26,741	5,693	7,796	1,244	920	1,902	695	14					202,154	1,069,594	26,073,386
Water turbines and waterwheels														475	No data	5,338,066

*From preliminary census reports.

Cleveland Engineers Holding Exhibit of Equipment

Electrical equipment and materials are the specialty for this month at the continuous exhibit which is being operated by the Cleveland Engineering Society in that city.

As an educational exhibit of engineering equipment and materials, many of the leading manufacturers of the country are displaying their products for the information of engineers and industrial executives of the Cleveland district. The exhibit hall is on the top floor of Carnegie Hall, adjacent to the clubrooms of the Cleveland Engineering Society, where many of the local sections of national societies are holding their meetings. This hall is open to the public every day from 8:30 a.m. to 8:30 p.m.

In connection with the exhibit, a special meeting will be held Tuesday evening, May 24, at which a demonstration and talk on "Recent Improvements in the Design of Portable Electric Tools" will be given by B. B. Ramey, chief electrical engineer of the Black & Decker Co., of Baltimore, Md. In his talk Mr. Ramey will tell about the development of high-cycle electric tools and how they have made possible for many types of work a speeding of production and a lowering of maintenance costs. This session is being held jointly by the Cleveland Engineering Society and the Cleveland Section of the Association of Iron and Steel Electrical Engineers. The Cleveland Section of the American Institute of Electrical Engineers is also co-operating.

Scotch Power Project To Test British Unification Plan

Scotland has been selected to initiate the British government's great scheme of consolidating and standardizing the country's electrical supply, which Parliament adopted last year, according to an Associated Press dispatch May 10.

The Electricity Board has just published details of the first scheme covering 70 per cent of the population and practically the whole industrial, shipbuilding and coal field areas of Scotland and supplying current to a population of nearly 4,000,000.

The scheme proposes to select and operate ten of the forty existing generating stations. Two new stations, capable of generating 100,000 kw., will be built, and it is estimated that by 1938 the total stations will be reduced to eight capital stations. These will be connected by a series of high-pressure main transmission lines, with co-ordination of supply and standardization of frequency.

The American practice will, as far as possible, be adopted of linking steam superpower stations in the proximity of the coal fields with the water-power stations to insure more continuous employment of natural power resources, as represented by the Clyde. The total estimated expenditure is $30,000,000.

Similar plans are under preparation for different sections of England with regard to the long-talked-of scheme of harnessing the Severn River tides for electrical power. Lieut. Col. Ashley, Minister of Transport, said recently in the House of Commons that it will only be possible to proceed with the investigation slowly, but he hoped that within "a convenient number of years" it might be possible to say whether such a scheme was practicable.

More Production, Fewer Trade Barriers—Urged at Geneva

Unanimity of opinion in the necessity of removing trade barriers and the stressing of the interdependence of nations appeared prominently among the first results of the opening of the International Economic Conference at Geneva, Switzerland, which sat May 4 with delegates from 47 countries including Soviet Russia, attending.

In his first report of the conference Edward J. Mehren, vice-president of the McGraw-Hill Publishing Co., Inc., who is attending the sessions in the interest of the readers of the McGraw-Hill publications, cabled, in part, as follows:

The first four days were devoted to a survey of the world's economic ills. There was general agreement that increased production was the indicated remedy, thereby increasing purchasing and consuming power and raising the standard of living. A striking note was the general solicitude for the well-being of workers, which was probably a new idea with European employers. The keenest analysis of the situation was made by W. T. Layton, editor of the *Economist*. He contended that we could not return to pre-war conditions. In his opinion a new equilibrium must be established.

Many Views Cited

Dr. Carl F. Von Siemens, of Germany, criticized government intervention in industry, which was particularly interesting as coming from the representative of a country where government assistance and compulsion are considered normal. Zimmerman, of Holland, cited increased government services and restrictive labor legislation as increasing the industrial burden by raising prices, restricting consumption and reducing trade. The remedies suggested were removal of government interference and reduction in number of non-productive public servants. Only Shidachi, of Japan, and Layton, of Great Britian, cited the wastefulness of armaments.

The speech of Henry M. Robinson, chairman of the American delegation, was well received. He sketched the development of our prosperous industrial situation, stressing the determination of American employers to secure needed economies by better management and machinery, but not by wage reduction.

It is not expected that the conference will have great or important immediate results, but that it will contribute to a better understanding of international problems and will lay a basis for some definite actions now and in the future. Three speakers advocated permanent organization for the study of international economic problems. The plenary sessions closed Saturday, May 7, and committee sessions on commerce, industry and agriculture began May 9.

N.A.S.E. Members Will Fly at Hartford Convention

Members of the Hartford branch of the National Association of Stationary Engineers, attending the meeting of the Society, June 24 and 25, will be offered a novel experience, when a number of them will be taken up in planes at the Connecticut State Aviation field. *Power* hopes that "such as 'em as is courageous" will breathe pleasurably and land safely!

The opening session will take place the evening of Friday, June 24. The following morning is slated for a business session. The great event follows in the afternoon, to be rehearsed again at the banquet in the evening.

Personal Mention

Frank G. Baum, who is a consulting engineer for the Westinghouse Electric & Manufacturing Co., recently left the United States for a business trip in Europe.

James S. Hedden, previously connected with the Marc Eidlitz Co., New York City, has recently joined the organization of Westcott & Mapes, Inc., as engineer in charge of construction.

C. L. Forbes, formerly of the efficiency department of the steam generation division of the Southern California Edison Co., has entered the production department of the Standard Oil Company of California.

F. H. Babcock, of the central station department of the General Electric Co., has been designated as assistant to Charles W. Appleton, who was recently elected vice-president in charge of general relations with public utilities.

E. L. Crowe, formerly mechanical engineer with the Sessions Engineering Co., has joined the staff of the Joseph Harrington Co., a subsidiary of the Whiting Corp., as sales engineer. Mr. Crowe is attached to the Chicago office at 1502 Railway Exchange Building.

Harry L. Shepard, formerly associated as engineer in the department of the chemist and engineer of tests of the Union Pacific Railroad, has been appointed technical representative in the Chicago territory of Reading Iron Co., Reading, Pa. Mr. Shepard is a member of the American Chemical Society.

William Buxman, manager of *Power* and for 19 years associated with the McGraw-Hill Publishing Co., became vice-president and general manager of the McGraw-Hill Catalog & Directory Co., May 11, replacing Robert Wolfers, who has resigned. Irving Fellner, formerly manager of *Chemical & Metallurgical Engineering*, succeeds Mr. Buxman as manager of *Power*.

Society Affairs

The Engineering Foundation Board at the University Club, New York City, will be presented by Dr. Arthur D. Little, president of Arthur D. Little, Inc., of

Cambridge, Mass., with a paper on "Impending Changes in Our Use of Fuels," May 19.

American Welding Society, Western New York Section, meeting at Buffalo, Hotel Statler at 8 p.m., May 17, will hear a paper presented by Lewis J. Sforzini, engineering department of the Eastman Kodak Co., comparing riveted and welded joints. Slides will be shown. Election of officers will also be held.

Business Notes

The C. J. Tagliabue Manufacturing Co., Brooklyn, N. Y., maker of industrial instruments, has opened a branch factory at 5902 Carnegie Ave., Cleveland, Ohio.

Westcott & Mapes, Inc., engineers and architects, 139 Orange St., New Haven, Conn., recently opened an office in the Woolworth Building, New York City. R. Wilbur Tietjen will be in charge of this office.

The Economy Pumping Machinery Co. has moved its principal manufacturing operations and the general office to its new plant, 3431 W. 48th Place, Chicago, Ill. The foundry and some specialized lines will be continued in the Joliet plant.

Link-Belt Ltd., Toronto, Canada, has appointed Jackson-Lewis Co., general contractors on the first unit of the building program of the company. The property is located at the corner of Eastern Avenue and Leslie Street, Toronto.

The Roller-Smith Co., 233 Broadway, New York City, announces that William H. Neville, Age-Herald Building, Birmingham, Ala., will cover the State of Alabama, and that the Atkinson Equipment Co., Atlanta Trust Company Bldg., Atlanta, Ga., will cover the State of Georgia.

General Air Filters Corp., 110 West 42nd St., New York City, recently appointed the Dingle-Clark Co., 311 Ross St., Pittsburgh, as representatives on ACE automatic, self-cleaning air filters, ACE unit-type stationary air filters, ACE compressor-type air filters for air compressors, internal-combustion engines and electric motors, as well as air washers, spray nozzles and spray ponds.

The Climax Engineering Co., Clinton, Iowa, has secured the services of Jack Redfern as sales representative. At one time, Mr. Redfern was sales manager of the Power Manufacturing Co. He has had an extensive experience in the sale of gasoline and oil engines and enjoys a wide acquaintanceship among engine users. At the present time he is on the Pacific Coast in the interests of the Climax organization.

The Galigher Co., 228 Southwest Temple St., Salt Lake City, Utah, is now a branch office of the Chain Belt Co., Milwaukee, Wis. This office will handle the sale of Rex chains, transmission machinery, Rex elevators and conveyors, and Rex traveling water screens in that territory. In addition, they will handle Stearns belt conveyors, which are manufactured by the Stearns Conveyor Co. at Cleveland, recently purchased by Chain Belt.

The Dampney Company of America, Hyde Park, Boston, Mass., announces that the sales of its Apexior protective coatings for power-plant equipment will be handled in the Detroit district by Coon-DeVisser Co., 2051 W. Lafayette Blvd., in the Cleveland district by A. MacLachlan Co., Union Trust Building, and in the Milwaukee district by Fred H. Dorner, 548 Milwaukee Street.

Coming Conventions

American Association of Engineers. Annual convention, Tulsa, Okla., June 6-8; M. E. McIver, 63 East Adams St., Chicago.

American Boiler Manufacturers Association. Annual meeting at French Lick Springs Hotel, French Lick, Ind., May 30-June 1.

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Pittsfield, Mass., regional meeting May 25-27. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Order of Steam Engineers. Annual convention, Moose Hall, 1314 North Broad St., Philadelphia, Pa. June 13-16; J. E. Burke, 1821 So. Ringgold St., Philadelphia.

American Refractories Institute. Spring meeting at Hotel Traymore, Atlantic City, N. J., May 18-19; D. A. Texter, secretary, 2202 Oliver Bldg., Pittsburgh, Pa.

American Society of Civil Engineers. George T. Seabury, secretary, 33 West 39th St., New York City. Annual convention at Denver, Col., July 13-15.

American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va., May 23-26. Calvin W. Rice, secretary, 33 West 39th St., New York City.

American Society of Refrigerating Engineers. Western meeting at White Sulphur Springs, W. Va., May 23-25, in conjunction with the Spring meeting of the A.S.M.E.; W. H. Ross, 35 West 39th St., New York City.

American Society for Testing Materials. Annual convention at French Lick Springs Hotel, French Lick, Ind., June 20-24; J. K. Rittenhouse, secretary, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. W. M. Niesley, assistant secretary, 170 Broadway, N. Y. Annual convention Hotel Sherman, Chicago, June 6-11.

Association of Iron and Steel Electrical Engineers. Annual convention at Pittsburgh, Pa., June 13-18, inclusive.

National Association of Practical Refrigerating Engineers. Annual convention probably in November; E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27; John Topman, secretary, convention committee, Ohio State annual convention in Memorial Hall, Lima, Ohio, June 16-18; P. H. Grigsby, secretary, Lima, Ohio. New England States convention at Portland, Me., June 17-18; Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass., Hartford meeting June 24-25, business sessions Saturday morning, aviation flight and banquet. Indiana State convention and power show at Anderson, May 27-28. Plainfield, N. J., meeting at Academy Hall, June 3-5.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., June 14-16 inclusive.

National District Heating Association. Annual convention at West Baden Springs Hotel, West Baden, Ind., May 17-20, inclusive; D. L. Saskill, secretary, Greenville, Ind.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Convention at Atlantic City, June 6-10; exhibition, June 4-10.

Universal Craftsmen Council of Engineers. Thomas H. Jones, secretary, 33 Linden Ave., Cherrydale, Va. Annual convention at Buffalo, N. Y. Aug. 2-6.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 9 1927
Pool 1	New York	$2.50@$3.00
Smokeless	Boston	1.70
Clearfield	Boston	1.60@ 1.85
Somerset	Boston	1.70@ 1.95
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.60@ 1.75
Pittsburgh	Pittsburgh	2.10@ 2.25
Pittsburgh gas slack	Pittsburgh	1.45@ 1.60
Franklin, Ill.	Chicago	2.50@ 2.75
Central, Ill.	Chicago	2.25@ 2.50
Ind. 4th Vein	Chicago	2.40@ 2.50
West Ky.	Louisville	1.50@ 1.75
S. E. Ky.	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.50@ 1.75
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.75@ 3.00
Buckwheat No 1	Philadelphia	2.50@ 3.00
Birdseye	New York	1.35@ 1.60

FUEL OIL

New York—May 12, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 5¾c. per gal. f.o.b. Bayonne, N. J.

St. Louis—May 4, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.53c. per gal.; 38@40 deg., 5.15c. per gal.

Pittsburgh—May 3, f.o.b. local refinery; 30@34 deg., fuel oil, 6c. per gal.; 36@40 deg., fuel oil, 6.25c. per gal.

Philadelphia—May 5, 27@30 deg., $2.25@$2.31 per bbl.; 13@19 deg., $1.75 @$1.81 per bbl.

Cincinnati—May 9, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—April 30, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.05 per bbl.; 26@30 deg., $1.10; 30@32 deg., $1.20.

Boston—May 9, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.43c. per gal.; 28@ 32 deg., 5.8c. per gal.

Dallas—April 30, f.o.b. local refinery, 26@30 deg., $1.75 per bbl.

The Crosby Steam Gage & Valve Co. announces the removal of the Chicago office to 547 West Randolph St., Chicago.

The Merco Nordstrom Valve Co. has removed its New York office from 110 West 40th Street to new quarters at 11 West 42nd St., New York City.

The Reading Iron Co., Reading, Pa., manufacturer of wrought-iron pipe, has removed its New York offices from 99 John St. to 30 Church St. The new space includes Rooms 318-320. H. S. Carland is district sales representative.

Jenkins Bros. regret to announce the retirement of Arthur C. Langston as an active representative of the company. Mr. Langston became associated with Jenkins Bros. almost thirty years ago, and since then he has enjoyed the acquaintance and friendship of the leading merchants in the supply line in the principal trade centers throughout the South.

Trade Catalogs

500,000 Lb. of Steam per Hour From One Unit — International Combustion Engineering Corp. has published in booklet form IC-2, an illustrated description of the work of remodeling one of the large steam generating units at the Fordson plant of the Ford Motor Co.

Sirocco Blowers for Oil Burners—The American Blower Co., Detroit, Mich., in Bulletin No. 1033 treats, with illustrations, of Sirocco blowers for domestic oil burners.

Portable Flight and Belt Conveyors—The Gifford Wood Co., manufacturer of elevating and conveying machinery for power and industrial plants, Hudson, N. Y., has issued a broadside featuring the company's WAGE$AVER line of portable flight and belt conveyors and wagon loaders.

Dry Grinding—The Hardinge Co., York, Pa., has issued bulletin No. 17-A in which are outlined the principles and described the methods employed for grinding various materials dry, with particular reference to the Hardinge conical mill and the reverse-current air classifier. By grinding dry is meant grinding a material containing a relatively small quantity of moisture, sufficiently small that it will not cause the product to become plastic or sticky. A short description of the various methods used is given.

Pyrometer Instruction — The Bristol Co., Waterbury, Conn., has published Bulletin No. 358 on the installation and care of pyrometers. The information given here is intended as a guide to users of Bristol's thermo-electric pyrometers in securing the greatest efficiency and satisfaction. Engineers can obtain the bulletin by addressing the company.

Stokers—The Riley Stoker Corp., 9 Neponset St., Worcester, Mass., has described in a recent catalog Riley underfeed super-stokers, in regard to which attention is called to such features as reciprocating retort side, all-live grate surface, two speed gear box, safety connecting rod for each retort, moving high side wall tuyeres, underlying grid grate blocks and flared retort sides. There are many views of the stoker in parts and assembled, together with several installations of various types depicted.

Bulk Storage Tanks—Graver Corp., East Chicago, Ill. This is the title of a new 48-page catalog issued on the subject of storage tanks. It contains a great many illustrations of bulk stations of every type. It also has a list of standardized tank sizes with specifications for all types. There are several pages devoted to drawings of station layouts. Structural steel supports are fully described. The book closes with a page on the care of tanks, with which is incorporated unloading and erecting suggestions.

New Plant Construction

Ark., Clarksville — City plans changing source of water supply from Spadra Creek to Big Piney Creek, including storage reservoir, pumps, mains, etc. Estimated cost $120,000.

Ark., North Little Rock (Little Rock P. O.)—U. S. Veterans Bureau, Washington, D. C., will soon award contract for the construction of addition to pump house, etc., here.

Calif., Long Beach—H. W. King, Orange, Calif., plans the construction of a 12 story hotel on Ocean Ave., here. Architect not selected.

Calif., Los Angeles—H. J. Latimer, et al, 1021 West 7th St., plans the construction of a hotel at West 7th and Garland Sts. J. Musgrove and W. J. Stevenson, New York, N. Y., are interested.

Calif., Venice — Venice Ice Co., W. O. Chaffee, Fiscal Agt., will build an ice plant at Washington and Victoria Sts. Estimated cost $75,000. York Products Co., 5051 Santa Fe Ave., Los Angeles, is architect and engineer. Work will be done by owners' forces.

Conn., Waterbury—Waterbury Hospital, Robbins St., will soon award contract for the construction of a 4 story, hospital. Estimated cost $625,000. F. A. Webster, 51 West Main St., is architect.

Ill., Chicago—Messrs. Roesca, c/o Hall, Lawrence, Rippel and Ratcliffe, 123 West Madison St., Archts., had preliminary plans made for the construction of a 13 story hotel including 2 elevators, etc., at 838 Wilson Ave.

Ill., East St. Louis—H. Redmond, et al, c/o Majestic Theater, is receiving bids for the construction of a theater building on Collinsville Ave. Estimated cost $500,000. Boler & Boler, New York, N. Y., are architects.

Ill., Evanston — W. Hayden Bell, 4336 South Kedzie Ave., awarded contract for masonry, etc., for an apartment at Ridge Ave. and Hull St. Estimated cost $500,000.

Ill., Evanston — Homestead Apartment Hotel Corp., c/o P. A. Danielson, 1569 Sherman Ave., Archt., awarded contract for masonry, etc., for a 7 story hotel at 1625 Hinman Ave. Estimated cost $700,000. Central refrigeration plant, elevators, etc., will be installed.

Ill., Kewanee — Illinois Power & Light Corp., S. M. Cox, Mgr., South La Salle St., Chicago, plans the construction of a substation and power plant, here. Estimated cost $150,000. E. S. Hight, c/o owner, is chief engineer.

Ia., Muscatine—City plans to submit to the voters the question of permitting the Central Steam Heat & Power Co. to install a central heating plant. Estimated cost $500,000.

La., Sterlington (Ouachita P. O.) — Louisiana Power & Light Co., Pine Bluff, Ark., will build two additional units to hydro-electric plant, 40,000 hp. capacity each, by day labor on the Ouachita River, here. Work will be done under the supervision of Ford, Bacon & Davis, 115 Broadway, New York, N. Y., Engrs.

Md., Baltimore—Alexander Hotel Co., c/o C. N. & N. Friz, Lexington St., Archts., awarded contract for the construction of a 10 story hotel to Consolidated Engineering Co., 20 East Franklin St. Estimated cost $650,000. Van Rensselaer Saxe, Knickerbocker Bldg., is engineer.

Mich., Detroit—Peninsular Stove Works, 1417 West Fort St., awarded contract for the construction of a plant including boiler house, boilers, etc. on Burt Rd., to Albert A. Albrecht Co., 1130 Penobscot Bldg.

Mich., St. Joseph—Hotel Whitcomb, will soon award contract for the construction of a 9 story hotel at Lake Blvd. and Ship St. Estimated cost $600,000. Pond, Pond, Martin & Lloyd, 6 North Michigan Ave., are architects.

Minn., Hibbing—City, J. O. Rivall, Clk., awarded contract for the construction of addition to power plant to Commonwealth Electric Co., 417 Broadway, St. Paul. Estimated cost $71,912.

Mo., Cape Girardeau — Hotel Securities Corp., Railway Exchange Bldg., St. Louis, awarded contract for the construction of a 6 story hotel at Broadway and Fountain St., to W. H. Smith-Nelson Cunliff Co., 110 North 7th St., St. Louis. Estimated cost $500,000. Steam heating system, etc., will be installed.

Mo., Kansas City—W. G. Wrenn, Rialto Bldg., will build an 8 story hotel at Armour and Harrison Blvds. by day labor. Estimated cost $600,000. P. T. Drott, Reliance Bldg., is architect. Steam heating, ventilation and refrigeration systems, boilers, pumps, elevators, etc., will be installed.

Mo., Macon—City plans waterworks improvements including pumping station, earth and riprap dams, mains, etc. Estimated cost $140,000. Burns & McDonnell, 400 Interstate Bldg., are engineers.

Mo., St. Louis — Evangelical Deaconess Home & Hospital, 4215 West Belle Pl., will receive bids in late summer for the construction of a 4 story hospital at Oakland and Clayton Sts. Estimated cost $800,000. T. P. Barnett Co., Arcade Bldg., is architect.

Mo., St. Louis—The Leopold Grossberg Real Estate Co., 705 Olive St., is having preliminary plans prepared for the construction of a hotel. Estimated cost $750,000.

Mo., St. Louis—Polar Wave Ice & Fuel Co., 3638 Olive St., awarded contract for the construction of an ice plant at Lee and Florissant Sts., to Gillespie & Daly, International Life Bldg. Estimated cost $55,000.

Mo., St. Louis—A. E. Lewis, c/o Lewis Realty Co., 4919 Natural Bridge Ave., will soon receive bids for the construction of an 8 story hotel including steam heating system, etc., at Spring St. and Natural Bridge Ave. Estimated cost $750,000. J. T. Craven Engineering Co., Century Bldg., is architect and engineer.

N. J., Teaneck (mail W. Englewood)—Holy Name Hospital will soon receive bids for the construction of a power house. Estimated cost $75,000.

N. Y., Albany—Dept. of Health, Capitol, Albany, will receive bids in June for the construction of a power house, etc.

N. Y., Brooklyn—Bush Terminal C 100 Broad St., New York, plans to expend from $10,000,000 to $20,000,000 for construction program over a period of 10 years, including industrial plants, factories, power plants, warehouses, etc., here. W. Higginson, 101 Park Ave., New York, is architect. E. M. Ellsworth, c/o owner, is engineer.

N. Y., Marbletown—Central Hudson Gas & Electric Corp., has been granted permit for extensions and improvements to electric light paint.

N. Y., New York—New York Evening Journal, 238 William St., is having plans prepared for the construction of a 6 story office building including steam heating system, boilers, pumps, elevators, etc., at 8th Ave. and 57th to 58th Sts. Estimated cost $1,500,000. George B. Post & Sons, 101 Park Ave. and J. Urban, 5 East 57th St., are associate architects.

N. D. Dickinson—City plans an election May 23 to vote $75,000 bonds for waterworks improvements including wells, 500,000 gal. reservoir, pumping equipment, etc. Burns & McDonell, Interstate Bldg., Kansas City, Mo., are engineers.

Okla., Bartlesville—City awarded contract for rehabilitation of waterworks system including pumping equipment, etc., to Repass Bros., 503 Frankel Bldg., Des Moines, Ia. Estimated cost $75,000.

Pa., Philadelphia—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until May 25, for the construction of an automatic refrigeration and cold storage plant at Navy Yard, here.

Pa., Philadelphia — Memorial Hospital, Ridge Ave. and Rector Sts., awarded contract for the construction of a 4 story hospital to Cramp & Co., Denckla Bldg. Estimated cost $230,000. Steam heating system, etc., will be installed.

Tenn., Nashville—Ralston Purina Mills, 4th Ave. S., awarded contract for the construction of a boiler room, etc., to Jones & Hellestater. Estimated cost $50,000.

Texas — Texas-Louisiana Power Co., Harris Trust Bldg., Chicago, Ill., plans the construction of a new power plant at Velasco, also a power unit at Brazonia, on the Brazos River, here. Estimated cost $75,000 and $35,000 respectively. Private plans.

Tex., Beaumont—W. C. Keith, awarded contract for the construction of a 12 story hotel at Pearl and Wall Sts., to S. W. Construction Co., West Bldg., Houston. Estimated cost $1,000,000.

Tex., Cisco — West Texas Utilities Co., Abilene, awarded contract for the construction of a 25 ton ice plant here, to L. Kearney, Cisco. Estimated cost $40,000.

Tex., Edinburg—Valley Refrigeration & Canning Co., A. W. Baker, is having preliminary plans prepared for the construction of an electrically operated refrigeration and canning plant. Estimated cost $60,000. Private plans.

Tex., Jasper—Eastern Electric Co., Beaumont, has acquired an electric power plant here and plans extensions and improvements. Estimated cost $25,000. Private plans.

Tex., McAllen—R. E. Horn, McAllen, and S. N. Hughes, Brady Bldg., San Antonio, are having preliminary plans prepared for the construction of a cold storage plant here. Estimated cost $60,000. Private plans.

Tex., Merkel—City will soon award contract for waterworks improvements including well, 80 ft. deep, 100,000 gal. reservoir, pump house, 300 or 175 g.p.m. well pump and 500 g.p.m. high service motor driven centrifugal pump, etc. Hawley & Roberts, Box 1115, Lubbock, are engineers.

Tex., San Antonio — W. J. Lytle, c/o Texas Theatre, plans the construction of a hotel at St. Marys and Travis Sts. Estimated cost $1,000,000. Boller Bros., 114 West 10th St., Kansas City, Mo., are architects.

Tex., San Antonio—Navarro Investment Co., J. A. Walker, Builders Exchange Bldg., plans the construction of a 14 story office building at Pecan and Navarro Sts. Estimated cost $1,000,000. Private plans.

Tex., Santa Anna—West Texas Utilities Co., Abilene, is having plans prepared for the construction of a 15 ton ice plant here. Estimated cost $40,000. Work may be done by owners' forces and electrically driven machinery and equipment will probably be required.

Tex., Sheffield—California Co., c/o Chamber of Commerce, Colorado, plans to divert 250 ft. (acre) of water per year from Pecos River for oil development including the installation of a pumping plant, etc., here. Estimated cost $35,000. Private plans.

Tex., Weslaco—W. Burns & E. W. Napier, Harlingen, awarded contract for the construction of a 65 ton cold storage plant here, to San Antonio Machine & Supply Co., 325 North Centre St. Estimated cost $60,000.

Vt., Castleton—Bd. of Education, will soon award contract for the construction of dormitory including central heating plant. Estimated cost $150,000. A. H. Smith, Gryphon Bldg., Rutland, is architect.

Wis., Milwaukee—St. Mary's Hospital, 144 Lake Drive, will receive bids about May 12 for the construction of a 5 story hospital and nurses' home including steam heating system, etc. Estimated cost $500,000. O'Meara & Hills, 1705 Arcade Bldg., St. Louis, Mo., are architects.

B. C., Kamlooks—Portland, Ore., Syndicate, represented by J. Muirhead, Engr., Birks Bldg., Vancouver, B. C., plans the construction of a hydro-electric development, 18,000 hp. capacity on the Adams River near here, also transmission lines, etc. Estimated cost $1,500,000.

Ont., Kapuskasing — Spruce Falls Co., Ltd., is having plans prepared for the construction of a hotel, hospital, clubhouse and school building including central heating plant, etc. Estimated cost $750,000. Roper Gouinlock, Continental Life Bldg., Toronto, is architect.

Ont., Ottawa—Canadian National Railways, Montreal, Que., plans the construction of a hotel on Rideau St. here. Estimated cost $4,000,000. J. S. Archibald, is architect.

United States & Mexico—United States and Mexican Governments, are having surveys made for irrigation and power project, involving 400,000,000 acres of land along the Rio Grande, Tia Juana and Colorado Rivers. Estimated cost approximately $125,000,000. M. E. Anderson, Gunter Hotel, San Antonio, Tex., is commissioner.

Equipment Wanted

Boiler and Motor—R. Freres, 215 Fortune Ave., Montreal, Que., is in the market for a 3 hp. steam boiler and 5 hp. electric motor.

Boilers—Dept. of Public Works, J. H. Sullivan, Comr., Boston, Mass., will receive bids until May 26 for boilers for ferryboat "John H. Sullivan." Estimated cost $25,000.

Compressors, Pumps, Etc.—Bd. of Commissioners, E. Read, Clk., Charlotte, N. C., will receive bids until May 24, for compressors, pumps, etc. for proposed addition to Sugar Creek sewage disposal plant and pumping station.

Engines and Generator—City of Purcell, Okla., voted $80,000 bonds for two new 400 hp. Diesel oil engines, generator and auxiliary equipment, etc.

Motors, Switchgears, Etc.—G. Richter, Moscow 34, Kropotkinstreet 37, United States Soviet Russia, wants prices and catalogs on a.c. and d.c. motors with accessories, switchgears and various electrical apparatus for power plants in paper industry.

Oil Burners—A. Le Bailly, Room 1412 Edison Bldg., Chicago, Ill., is in the market for oil burners for furnaces, boilers, building heating.

Power House Equipment—Canadian National Railways, Montreal, Que., L. Lavoie, Gen. Purch. Agt., is in the market for complete equipment for power house at Edmonton, Alta.

Pump — M. F. MacQuiddy, Clk. Hope School Dist., Santa Barbara, Calif., plans to purchase a 20 g.p.m. double acting pump.

Pump and Motor—City of Alters, Okla., S. E. Hickman, Mayor, is in the market for a 1,000 g.p.m. centrifugal fire pump and 100 hp. motor.

Pumping Equipment—City of Monrovia, Calif., will be in the market for pumping equipment, etc., for proposed waterworks improvements. Estimated cost $15,000.

Pumping Equipment, Etc. — City of Monette, Ark., will be in the market for pumping equipment, etc., for proposed improvements to waterworks and sewage systems. Estimated cost $65,000.

Pumping Equipment, Engines, Etc.—G. C. Hagelstein, Broadway Ave., San Antonio, Tex., plans the installation of pumping equipment, crude oil and gas engines, etc. in connection with irrigation project.

Pumping and Water Measuring Equipment—M. W. Malyshev, Samjatin 4, log. 45, Leningrad, United States Soviet Russia, wants prices and catalogs on pumping and water measuring equipment for water power utilization.

Pumps—City of Forest Hill, Ont., will be in the market for electrical centrifugal pumps for proposed sewage pumping station. Estimated cost $96,000.

Pumps, Etc.—City of Berryville, Ark., will be in the market for pumps, etc. for proposed waterworks improvements. Estimated cost $50,000.

Pumps, Motors, Engines, Etc. — W. H. McNab, Pres. of City Council, Pompano, Fla., will receive bids until May 19, for one 750 g.p.m. centrifugal pump and motor, one 750 g.p.m. centrifugal pump and engine, etc. for proposed waterworks improvements.

Water, Light & Power Plant Equipment—W. Eaton, Sonora, Tex., is in the market for machinery and equipment for water, light and power plants recently destroyed by storm. Estimated cost $45,000.

Water and Light Plant Equipment—C. B. Steele, Utility Supt., City Hall, Anderson, Ind., new equipment and repairs for water and light plant. Estimated cost $85,000.

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